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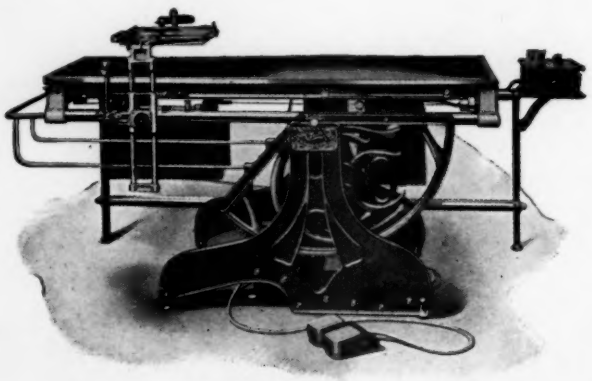

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THE AMERICAN JOURNAL OF ROENTGENOLOGY

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THE VALUE OF THE ROENTGEN RAY IN THE STUDY OF DIVERTICULITIS OF THE COLON*

THE RECOGNITION OF DIVERTICULITIS AS A CLINICAL ENTITY; CONSTIPATION AS AN ETIOLOGICAL FACTOR; PATHOLOGICAL CHANGES; SYMPTOMS; DIFFERENTIAL DIAGNOSIS; RADIOGRAPHIC CLASSIFICATION OF MULTIPLE DIVERTICULA; BIBLIOGRAPHY.

BY ARIAL W. GEORGE, M.D. AND RALPH D. LEONARD, A.B., M.D.

BOSTON, MASS.

THE term "multiple diverticulitis" when applied to the large intestine refers to the presence of one or more sacculations projecting from the exterior of the gut, together with their secondary inflammatory changes. As many of these pathologic sequelae involve the tissues around the intestine, "peridiverticulitis" might be a more apt term.

Diverticulitis to-day occupies an important place in medical literature and it is recognized as a distinct clinical entity by every operating surgeon of large practice. It is only within the past twelve or fifteen years that the profession has had an intelligent appreciation of the importance of this condition, although Graser presented in 1898 a fairly accurate clinical and pathological description of "diverticulum formation" in the large bowel and showed that such cases were not uncommon.

Previous to Graser's work, however, the literature on "diverticulitis" consisted in the occasional report of isolated cases. Virchow in 1853 described certain "pathologic changes involving the descending colon and the sigmoid characterized by isolated, circumscribed, adhesive peritonitis." He even described some of the possible complications, adhesions, constrictions, perforation, etc. He did not, however, note the presence of diverticuli as the original cause, considering constipation as the etiologic factor; neither did he attempt to describe the clinical picture.

From 1900 on many important contributions were offered, particularly by American observers. Fisher in 1901 and Beer in 1904 did experimental work on the etiology of the intestinal diverticula. In 1907 the Mayos, Wilson and Giffin reported several operated cases of diverticulitis, contributing particularly to the clinical aspects of the disease. In the same year Brewer offered a paper also describing the clinical manifestations of diverticulitis entitled "Etiology of Certain Cases of Left-sided Intra-abdominal Suppuration." In the following year Ashhurst reported a case of "Sigmoid Diverticulitis" in a child. This patient is the youngest case

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on record. McWilliams about the same time reported cases emphasizing some of the serious sequelae.

Telling in 1908 for the first time collected and analyzed the recorded cases, classifying the pathologic changes and clinical results. This classification has furnished the basis for most articles of importance written since that date. In 1911 Telling and Gruner amplified this classification, basing their conclusions on a much larger number of cases.

During the last seven or eight years there have been many contributors to both the clinical and pathologic features of "multiple diverticulitis," among whom are Mayo, Wilson, Giffin, Hartwell and Cecil, Graves, Erdmann, and particularly McGrath. His paper on the "Etiology and Pathogenesis of Colon Diverticula" is especially valuable.

The *x*-ray as a means of diagnosis of multiple diverticulitis was first brought to our attention by Dr. L. T. LeWald, who made a roentgen diagnosis of sigmoid diverticulitis in a case reported by Abbe in August, 1914.

Carman, in November of the same year, and Case, in the following year, described the radiographic appearance of multiple diverticulitis of the colon. Since then a few contributions on this subject have been made by roentgenologists to periodicals and textbooks. These papers, however, are in the nature of reviews and confirmation of Carman's and Case's work, and offer nothing particularly new.

In order better to understand the radiographic appearance of multiple diverticulitis, it may be wise to consider some of the pathologic aspects. The following statements and classifications represent in general a résumé of the more recent contributions to the pathology and etiology of this disease.

Diverticula may be classified in two general groups—the congenital group and the acquired group. The congenital group is small. Meckel's diverticulum in the small intestine and a few other developmental anomalies, such as a persistent urachus, compose this class. These congenital diverticula do not enter into the scope of the present paper.

As Dr. Charles Mayo states: "The various viscera and tubular structures of the body are subject to acquired diverticula. Even the large blood-vessels are prone to this condition in the form of sacculated aneurysm."

The group of acquired diverticula comprise practically all the diverticula which are of clinical importance. The esophageal diverticula, the various diverticula of the duodenum, ileum, and the multiple diverticula of the large intestine, in which we are particularly interested, belong to this group.

The acquired diverticula are further described as "true" or "false," these terms being used with reference to the structure of the walls of the diverticulum, as compared to the structure of the walls of the normal organ. Some pathologists use the terms "complete" and "incomplete" synonymously with "true" and "false."

A "complete" diverticulum presents in its walls the same tissues and the same arrangement of lining membranes as the normal intestinal wall. The "incomplete" or "false" diverticula consist of but part of the elements found in the normal intestinal wall. The diverticula of the colon probably belong to this latter group, their walls being composed of merely the mucous and serous coats. There is no "muscularis" as found in the normal intestinal wall. McGrath speaks of these diverticula as "hernia mucosae."

It has been suggested that originally they were "true" diverticula, the muscle coat simply atrophying from disuse. In view of the probable etiology of diverticula we feel that the idea of "muscle atrophy" is unlikely.

Diverticula of the large bowel may be found in any division of the large intestine, but are most commonly found in the descending colon and sigmoid. McGrath's figures in a series of 32 cases are typical. In 27 cases diverticula were found in the descending colon and sigmoid, 2 cases in the rectum, one case in the transverse and hepatic flexure, and one in the anal ring.

Our observations as radiologists would lead us to believe that diverticula occur in the ascending and transverse colons more frequently than has generally been believed.

The diverticula in this location, however, are less likely to give symptoms than in the descending colon and sigmoid, hence do not come to the attention of the surgeon or pathologist.

The number of diverticula present may vary from 1 to 100 or more. Hauseman found 400 at autopsy in a man of eighty-five

FIG. 1. DIVERTICULA OF SIGMOID. The pouches are, for the most part, into the appendices epiploicae. (Taken from Maxwell Telling and Gruner, *British Journal of Surgery*, Vol. iv, No. 15.

dying from pneumonia. It is generally agreed that colon diverticula are multiple and that 10 to 20 are the average number found.

They vary in size from a small fraction to two or more inches in diameter. The tendency is gradually to increase in size, the earliest stages being microscopic. The average size found at autopsy or operation is about that of a pea.

They are of variable shape, being usually round or ovoid. Some are distinctly pedunculated, with a minute opening into the lumen of the intestine.

The contents of these pockets are almost entirely fecal material, the consistency of which is variable. Occasionally the fecal material becomes so inspissated as to produce fecaliths. McGrath speaks of "concretions becoming incapsulated within the diverticula and, the pedicles sloughing, give rise to free bodies in the abdominal cavity." Numerous

FIG. 2. PORTION OF DESCENDING COLON. Specimen laid open to show the internal orifices of the diverticula. (Taken from Maxwell Telling and Gruner, *British Journal of Surgery*, Vol. iv, No. 15.

writers have reported foreign bodies in the diverticula.

The diverticula project from the exterior of the gut, usually close to the mesenteric attachment (Figs. 1 and 2). They may be found between the two layers of peritoneum forming the mesentery. It is also observed that the diverticula are in close proximity to the epiploic appendices.

Under the microscope the walls of the diverticula are seen to consist of mucosa, usu-

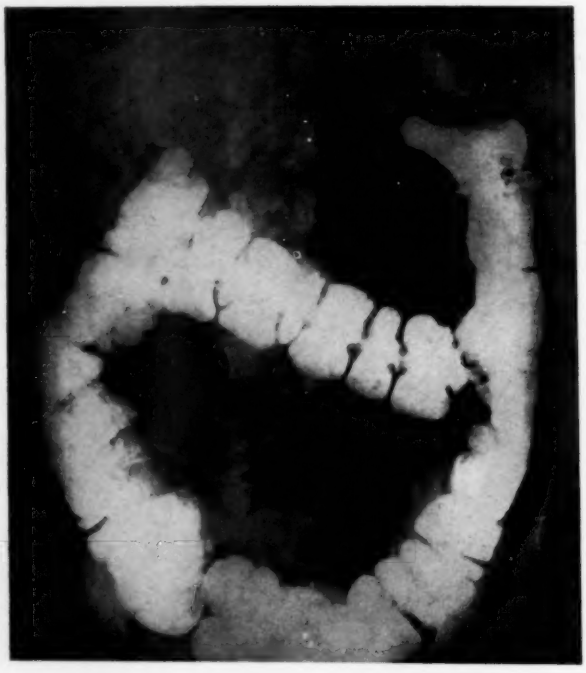

FIG. 3. NORMAL COLON. Plate made following a barium enema.

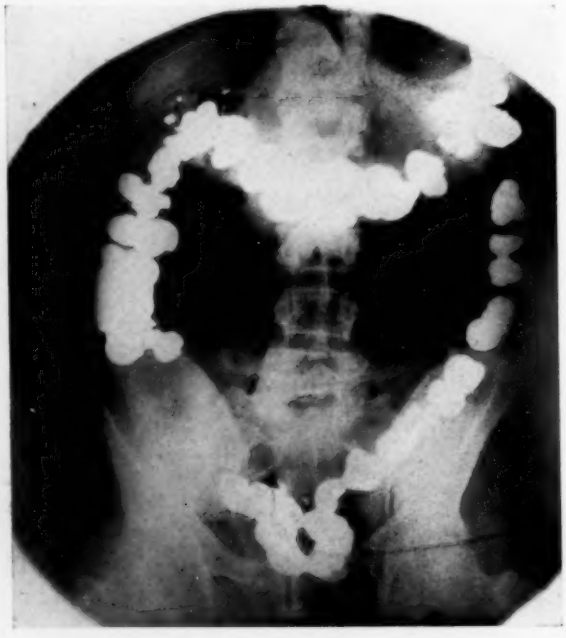

FIG. 4. NORMAL COLON. Plate made twenty-four hours after a barium meal.

ally submucosa and serosa. There is complete absence of smooth muscle-fiber. In some of the larger diverticula the lining of epithelium is more or less obliterated, due to the continued pressure of the fecal contents.

There is no obvious reason for believing that the formation of a simple colon diverticulum will necessarily be the source of symptoms. In fact, we frequently find evidence of diverticula on the *x*-ray plate without the patient presenting any local symptom. It is apparent that only when pathologic changes take place that are secondary to the diverticula do the patients complain. It is difficult to estimate what percentage of diverticula have inflammatory changes such as to produce symptoms. Telling estimates that 60 per cent of all persons having colon diverticula may have symptoms.

It is clear, therefore, that the recognition of inflammatory sequelae is of utmost importance in the consideration of multiple diverticulitis. In general, the various secondary changes and complications are the result of infection through the walls of the diverticula. They have been classified for convenience in various ways. The following is as typical as any:

(*a*) *General peritonitis* may be produced by the actual passage into the peritoneal cavity of bacteria or their toxins through the thinned-out walls of the diverticula, some of the walls being so thin as to consist only of peritoneum.

(*b*) Acute gangrenous inflammation may result from strangulation at the neck of the pedunculated type of diverticulum.

(*c*) The chronic proliferative extramucosal inflammation is the most constant pathologic process. Telling considers this condition the most important. These proliferative changes produce in time large palpable masses. These masses tend to surround the gut. Embedded in them are the diverticula. Later they tend to actual intestinal obstruction. It is this type of in-

flammation to which the term "peridiverticulitis" applies, and it is this complication which is frequently diagnosed as cancer or sarcoma.

(*d*) It is evident that, with a mass of connective tissue in close proximity to other organs, adhesions involving these organs will arise. The bladder, small intestine, and pelvic organs are the viscera most commonly affected.

(*e*) Perforation is one of the most serious complications. This may be *acute*, perforation taking place through the thinned-out diverticulum wall or possibly through an ulcerated area. This type of perforation may follow severe strain. Chronic perforation may slowly take place into the peridiverticular mass of connective tissue. This may be associated with abscess formation. Fistulae connecting the colon with the bladder or small intestine may follow a chronic perforation.

(*f*) Chronic inflammation of the mesentery as a complication of diverticulitis has been reported by several, among them Telling and McGrath. The late changes in mesenteritis are of importance, in that contracting bands of connective tissue in the mesentery may be an etiologic factor in the production of some cases of volvulus.

(*g*) The development of *cancer* on the inflammatory mass is a possibility. The condition is analagous to the development of cancer on a chronic indurated gastric ulcer. McGrath reports that in his series of advanced peridiverticulitis with formation of a mass of connective tissue, 25.9 per cent showed evidence of malignancy.

Beer, Wilson, Telling, Giffin, McGrath, Hartwell, and Cecil have all presented theories as to the cause of diverticula. The following factors are worth consideration:

1. Age: Most cases occur in people beyond middle life. Occasional cases

FIG. 5. NORMAL COLON. Plate made after a barium meal. Some hypertonicity. Note appearance of haustra in transverse colon, likely to be confused with diverticula.

FIG. 6. NORMAL COLON. Following a barium enema. Note the atonic condition of the intestinal walls.

FIG. 7. MULTIPLE DIVERTICULA. Plate made twenty-four hours after meal. Diffuse distribution of the diverticula over transverse colon, descending colon and sigmoid. Simple diverticulum formation without inflammatory changes. Class I.

are reported in patients under thirty. Ashhurst reports a possible case of seven years.

2. Males are twice as susceptible to diverticula as females.

3. Obesity seems to be a definite predisposing cause; on the other hand, rapid loss of weight may be followed by diverticulitis.

4. The normal muscle structure of the colon, particularly the arrangement of the muscle-fibers, is thought to predispose toward diverticulum formation.

5. The physiologic rôle of the sigmoid, in that it contains gas and fecal material under more or less pressure, may be an etiologic factor.

6. The points of entry for blood-vessels passing through the intestinal wall seem common sites for diverticula. These points of entry are also close to the appendices epiploicae.

7. Another predisposing factor may be a variation in the size of the blood-vessels as found in congestion from venous obstruction, or high arterial pressure in cardiorenals or advanced arteriosclerosis.

8. There may be a congenital predisposition.

9. Simple muscle weakness in the intestinal wall may have a causal relation to the presence of diverticula.

One or all of the above factors may be involved in the production of diverticula. In general, herniae of any kind are the result of *increased pressure* within a cavity plus a *local weakness* in the wall. In the region where diverticula most commonly occur (the sigmoid) the intestine is subject to *increased pressure* from accumulating feces and gas.

Weakness in the wall may be produced by localized fatty degeneration of the muscle; degeneration from cachexia; the foramen for the blood-vessels with the coat of connective tissue are less resistant than the surrounding muscle-fiber, etc.

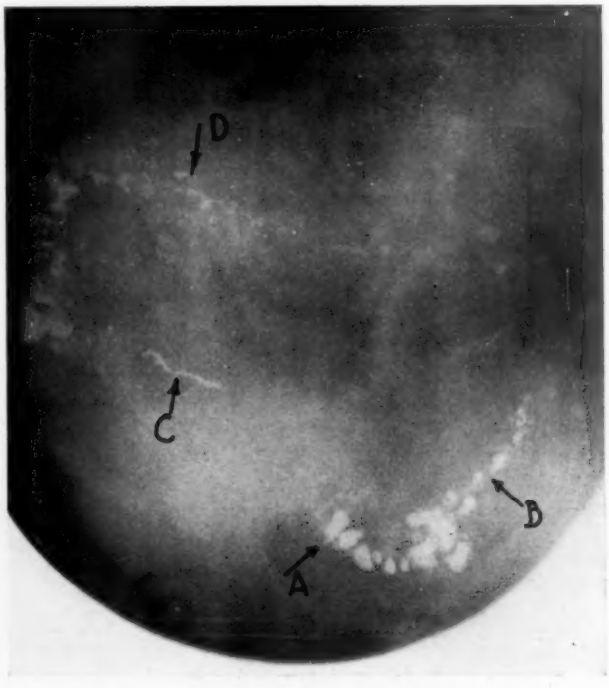

FIG. 8. MULTIPLE DIVERTICULA. Plate made twenty-four hours after barium meal. A few simple diverticula diffusely distributed at *A*, *B* and *D*. Appendix visualized at *C*. Patient has no symptoms. Class I.

Multiple diverticulitis presents a fairly definite clinical picture. The average age of the patient is from forty-five to sixty, and in general there is a marked tendency to obesity. In our cases diagnosed by the *x*-ray, the majority of the patients weighed about 200 pounds. Men seemed more susceptible than women.

A history of chronic constipation is found in about one-quarter of the cases. A picture of chronic obstruction with alternating diarrhea is suggestive, the chronic obstruction being from the secondary connective tissue changes.

Pain is present in a large percentage of cases. In the chronic type there is frequently a long history of attacks of crampy pain in the left lower quadrant. About 15 per cent give a story of abdominal pain of considerable severity. It must be remembered that symptoms are the result of the secondary pathologic changes. These may vary all the way from acute peritonitis to acute obstruction, so that the symptoms of pain may be variously manifested.

FIG. 9. MULTIPLE DIVERTICULA. Plate made twenty-four hours after barium meal. No symptoms; no inflammatory changes. Class I.

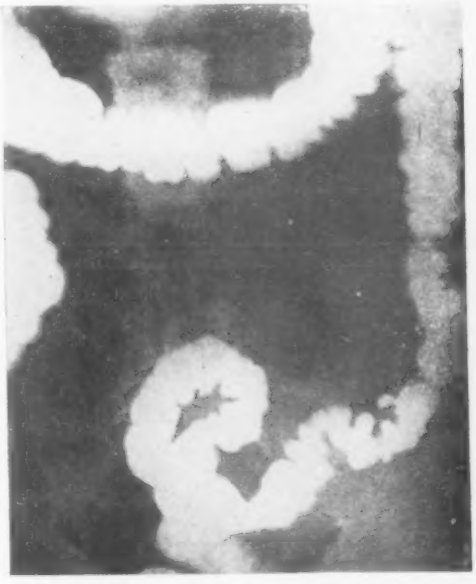

FIG. 10. SIMPLE DIVERTICULUM. Plate taken after barium enema. Class I.

The simple diverticula without secondary inflammation changes probably do not give symptoms.

A palpable tumor in the left side is found in about 30 per cent of the cases giving symptoms. It is usually an elongated "sausage-shaped" mass lying commonly just above and more or less parallel with Poupart's ligament. Frequently it is mobile. A characteristic of this tumor is its variability. It may appear and disappear several times, its appearance being accompanied by signs of inflammation.

Abscess formation, local peritonitis, obstruction, etc., all show their usual clinical signs of fever, leukocytosis, pain, etc.

Rectal examination is negative in all cases except where there is actual diverticulum formation in the rectum itself. The proctoscope reveals nothing.

Multiple diverticulitis is mainly an extra-mucosal disease of the intestine, so that commonly the mucous membrane remains intact. As a result the passage of macroscopic blood is not commonly associated with diverticulitis. This is an important point in the differentiation of cancer. Carcinoma is a mucosal disease and associated with bleeding.

FIG. 11. MULTIPLE DIVERTICULA. Plate made after a barium enema. Two diverticula seen. Class I.

FIG. 12. MULTIPLE DIVERTICULA AFTER A BARIUM ENEMA. A few small diverticula. Class I.

In the differential diagnosis carcinoma of the colon is the important condition to be ruled out. The pathologists tell us that possibly 25 per cent of the chronic indurated diverticulitis cases become malignant.

But, in general, a patient who is well nourished and continues to maintain good nutrition in spite of symptoms; who has a long pain, localizing in the left lower quadrant; who presents at times a palpable mass in the lower left quadrant; usually who has not passed macroscopic blood; who may present evidence of vesical fistulae, and with a negative sigmoidoscopic examination—such a patient may reasonably have made a diagnosis of chronic proliferative diverticulitis.

In carcinoma of the colon there is usually an early loss of flesh. Pain is not a constant symptom until obstruction sets in. Tenderness is a late finding. Blood, on the other hand, may be an early finding. When tumor is present, it is permanent.

From the other forms of pelvic inflammation it may be difficult to differentiate multiple diverticulitis. Left-sided appendix can usually be ruled out by the *x*-rays. In the presence of a palpable left-sided tumor one must always consider diverticulitis.

Up to the present time roentgenologists have perfected no special technique for viz-

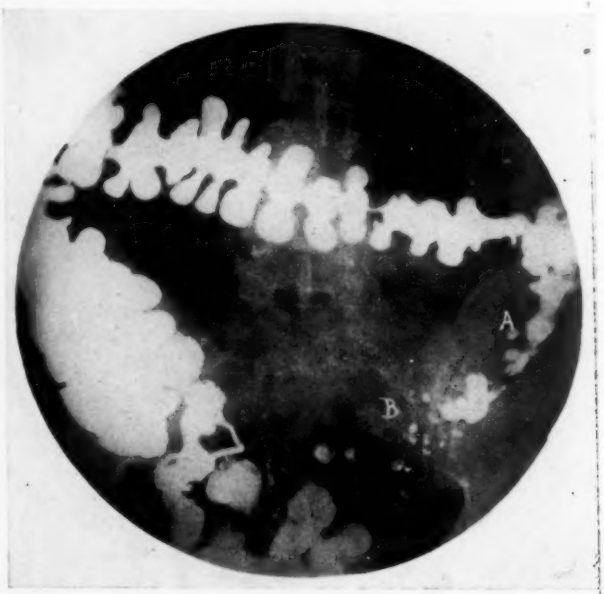

FIG. 13. MULTIPLE DIVERTICULA. Plate made twenty-four hours after barium meal. Note that the diverticula are definitely localized at junction of descending colon and sigmoid *A* and *B*. There is narrowing of the lumen of the colon from inflammatory tissue and spasm. Class II.

FIG. 14. MULTIPLE DIVERTICULA. Condition similar to Fig. 13. Class II.

ualizing colon diverticula. Such cases of multiple diverticulitis as have come to our attention have been found in the course of routine *x*-ray intestinal examination.

For those roentgenologists who do not make a routine practice of radiographing the abdomen previous to the administration of the barium meal we wish to emphasize the importance of this preliminary study. Just as preliminary routine plates of the right upper quadrant will usually visualize a gall-stone, so plates of the left lower quadrant oftentimes will give evidence of importance in the question of multiple diverticulitis.

From the pathology we learn that fecaliths may be found in the diverticula due to the prolonged retention of fecal material. On account of the deposition of calcium the fecaliths are capable of casting distinct shadows on the *x*-ray plate. Unless preliminary plates are made such shadows will be obscured by the barium meal.

Diverticula which have become separated from the intestine and are free bodies in the abdominal cavity may produce a shadow on the plate. Their free movement will be demonstrated.

These preliminary plates may also reveal shadows which later in the examination might lead to confusion unless their presence had been previously recognized. Calculi in the left kidney or ureter; calcified glands, retroperitoneal or mesenteric; phleboliths; sclerosis of iliac arteries—all may produce shadows somewhat simulating the contents of diverticula.

The plates should be made both on the front and back. In our experience an intensifying screen allows us to use a little less penetrating ray, resulting in a more contrasty plate. This additional contrast, slight as it may be, frequently makes all the difference between showing and missing an obscure shadow. The fluoroscope helps in differentiating a movable and fixed shadow, and particularly in determining if it moves with respiration.

After the preliminary examination the patient is given the opaque meal. The meal which has been used routinely for several years in general gastrointestinal examina-

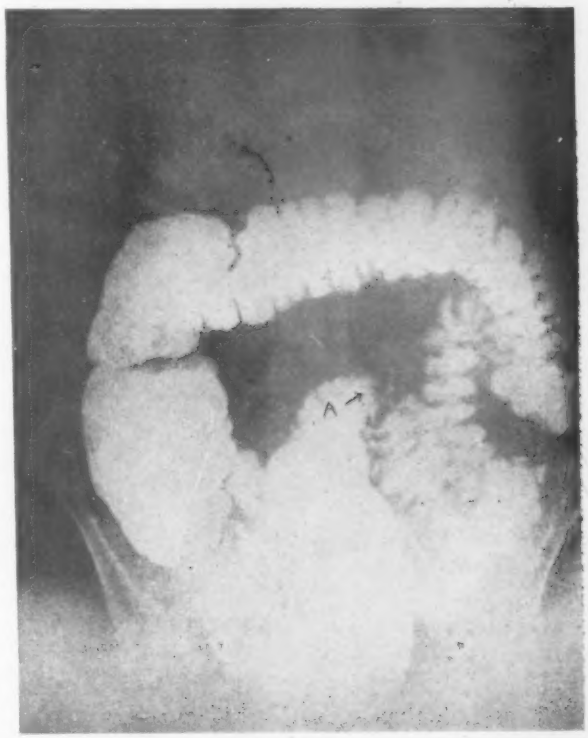

FIG. 15. MULTIPLE DIVERTICULA with beginning narrowing of the colon at *A*. Plate made following the barium enema. Rather diffuse distribution of the diverticula throughout the descending colon and sigmoid. Class II.

FIG. 16. MULTIPLE DIVERTICULA. Plate made after barium enema. Localized diverticula at *A*, with narrowing of the lumen mainly due to spasm. Phleboliths at *B* might be confused with diverticula, unless their presence had been previously recognized in the "preliminary examination."

FIG. 17. MULTIPLE DIVERTICULA. Plate made after the barium meal. Isolated diverticula at *A* and *B*. Secondary inflammatory changes involving descending colon. Class II.

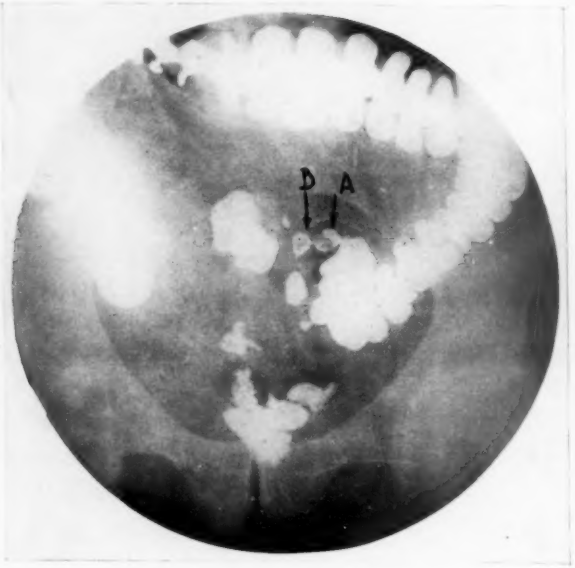

FIG. 18. LOCALIZED DIVERTICULA FORMATION. Plate made after barium enema. Two diverticula at *A* and *B*. Narrowing of the colon at this point. Symptoms of chronic obstruction. Class II.

tions has proved satisfactory for the demonstration of colon diverticula. It consists of two glasses of buttermilk and 1½ ounces of barium sulphate in each glass. This is taken on an empty stomach. With the buttermilk meal the appendix is more readily filled than with other meals, so it is likely that diverticula are more readily filled with this type of meal.

Twenty-four hours after the meal we find the best filling of the colon. It is on this plate that the diverticula are first visualized. As a frequent site for the diverticula is near the mesenteric attachment, it is obvious that in a simple antero-posterior plate these shadows may be hidden by the mass of barium filling the lumen of the colon. Palpation under the fluoroscopic screen or stereoscopic plate may bring to light some of these hidden diverticula (Figs. 3-6).

As these pockets tend to retain the barium over a prolonged period, we have found that plates made thirty-six to forty-eight hours after the meal show the diverticula to the best advantage. At this time the lumen of the colon will be entirely free of the barium meal, and the barium-filled diverticula stand out clear and distinct.

FIG. 19. DIVERTICULA AT *A* AND *B*, with narrowing of the colon at *B*. Barium enema. Class II.

It is of importance to determine the length of time barium is retained in these pockets. This, of course, is variable and depends upon the type of diverticulum. We have observed cases where plates made not only days but weeks after the meal still showed evidence of barium in the diverticulum.

The examination with the barium meal should always be followed up with the barium enema. The enema is not so satisfactory as the meal for visualizing the actual diverticula. The pockets do not fill readily, perhaps for the same reason that the appendix is not filled by the enema. Again, the colon is usually so distended by the enema that the mass of barium very easily obscures many of the diverticula. The enema is of value, however, in bringing out some of the secondary pathologic changes, such as chronic thickening of the intestinal wall, with narrowing or beginning obstruction; abscess cavities, chronic perforation, fistulae, etc.

Our practice is to mix up 5 or 6 ounces of barium with a pint of buttermilk and water enough to make a quart. This is given slowly with very little pressure; the elevation of the container is usually not more than two feet above the table. A soft rubber rectal tube is used, the end being inserted just beyond the internal sphincter. The patient, if possible, lies on the left side.

This solution is not irritating, and the patient usually retains it comfortably for 10 minutes or more. Plates and study with the fluoroscope are made immediately. In fact, it occasionally gives valuable information to watch the abdomen with the fluoroscope as the enema is being given.

The patient is next asked to empty the colon as completely as possible, and further plates are made. These last plates will visualize any diverticula which retain the barium, and also give us information as to the ability of the patient to empty the colon.

(*To be concluded in the October issue.*)

ELECTRICAL DANGERS IN X-RAY LABORATORIES

By J. S. SHEARER, B.S., PH.D.

ITHACA, NEW YORK

THE recent death of Dr. Jaugeas by electrocution in an *x*-ray laboratory in Paris has served to direct attention to the danger in the operation of *x*-ray devices where proper precautions are neglected, or where the idea of safety is based on misconception of the fundamental facts involved. In the July, 1917, number of this JOURNAL the writer described briefly the sources of danger and pointed out some remedies. It is interesting to note the following review of this article in the *Journal de Radiologie et d'Electrologie:*

"The author describes what might happen if the patient were subjected to an accidental spark. Without denying the extreme unpleasantness that would result from a short circuit between the patient and one of the high tension wires we may remind the author that confiding the operations in radiology only to a technician of experience, and continuous oversight of the patient and the apparatus, are, in practice, infinitely more efficacious than the automatic methods he prescribes. *Moreover one has never yet recorded, to our knowledge, a fatality due to contact with a high tension circuit used in radiology.*"

The death of Dr. Jaugeas and of several others less widely known, and the serious injury to patients in numerous instances, is sufficient answer to the ideas advanced in this review, especially as Dr. Jaugeas had had many years' experience. As a matter of fact very few roentgenologists have acquired reliable information on this important subject. On this account, and because of the rapid introduction of low power apparatus, it has seemed advisable to extend the remarks of the previous article even at the risk of some repetition.

While it is true that serious accidents in the operation of modern *x*-ray apparatus have not been numerous, yet the relatively small number of injuries is a matter of good fortune, as opportunities for contact with dangerous conductors have been extremely general.

There is evidently much misunderstanding as to what is or is not dangerous in this connection, resulting in advice often misleading, and, if followed, more likely to increase danger than otherwise. The result of an electric shock will depend in part on the condition of the subject, in part on the current and its duration, and also on the path followed by the current between the areas where current enters and leaves the body. Death is usually regarded as due to action on the heart and respiration, consequently the condition of the heart will be a large factor in the matter. Not only may death be due to an actual lesion, but a fatal result may follow from fright. On this account one is hardly justified in placing a lower limit on the voltage to be regarded as dangerous. Cases are on record where death has been caused by contacts with an alternating power circuit of less than 100 volts. Such cases may be difficult to explain, just as in the case of survival after contact with very high voltages that have not given a fatal result. Yet no one cares to assume that a given individual would not be killed or injured by such shock.

Keeping in mind the possibility of death from comparatively low tension circuits, it is clear that the operation of *any* *x*-ray tube at the voltage and power needed for fluoroscopic, radiographic or therapeutic work requires an outfit *potentially* dangerous. The only exception would be where the *entire* outfit is surrounded by a grounded metal shield or by a complete insulator. For some work such equipment may eventually be realized, but the present appliances must be used for a long time at least.

Leaving out of account the relatively rare cases where ordinary voltages give a fatal shock, it is generally agreed that a current of 100 ma. *maintained* through the vital organs for a few seconds or less is practically sure to be fatal. There have, no doubt, been numerous instances where a current greater than this has not resulted in death, but at any rate one would not care to risk it.

The current through the body will depend on:

1. The resistance of the body, including the contact resistance where current enters and leaves the skin.

2. The voltage at each instant tending to force current from the point of entry to the point or region where it leaves.

The total resistance of the body may be as low as 5,000 ohms depending largely on the area of contact, on the dryness of the skin and on the individual. Thus to originate and maintain a current of 100 ma. we must have 500 or more volts between the points of entry and emergence. Note that any voltage is more dangerous if maintained for more than a brief instant. Although a static machine will give many kilovolts on open circuit it can not maintain voltage when a few milliamperes are drawn and there would be little chance of serious result to a person in good health from contact with its terminals. Most induction coils in the early days were so designed as to give long spark gap on open circuit, but there was very little maintained voltage on an external resistance as low as that of the human body; thus they were not specially dangerous.

A Leyden jar or other condenser charged to several thousand volts may be discharged through the body causing an unpleasant shock but with little danger, as the voltage not being sustained by a generator there is only a brief rush of current rapidly falling to zero.

It should be noted that a high voltage applied to one point of the body when insulated from all other contacts, thus charging the body to a high potential, is not necessarily dangerous. One can stand on an insulated stool and receive a current charging the body to many thousand volts without danger. But the *maintained* flow of charge through the body is quite a different matter.

In order to understand the reasons for not doing certain things that increase danger, it may be well to consider the fundamental features of an electric circuit.

First, one should note that all electric charge comes from matter being separated from atoms by certain agencies known as generators. The amount thus separated is a very small fraction of the total charge bound up with the atoms of even a limited amount of material. Thus if all existing generators were set to pumping charge of one sign, say from the earth to some other body, the effect on the electrical condition of the earth would be negligible, much as though all the existing pumps were set to pump out the ocean—the resulting change in sea level would not be noticeable even if no water *ran back*. We therefore consider the earth as in a stationary electric condition. This is expressed by saying that earth *potential* is always zero, exactly as we use sea-level as a starting point for measuring levels. When an electric charge tends to move to or from the earth the body on which this charge is located is said to be at a *potential* of a certain number of volts. If a point on any conducting system is joined by a conducting path to the earth that point is said to be brought to *zero potential*, or is grounded.

The function of a generator, battery, dynamo, or transformer is to create differences of potential by the separation and movement of charge, thereby causing and maintaining electric current when conditions permit transfer of charge by any outside conducting path.

To illustrate, consider first the *primary* circuit of the usual *x*-ray transformer. The generator (Fig. 1) causes a voltage or potential difference of 220 volts between its terminals; a portion of this may be used in the control resistance, the rest is consumed in the primary. This *distribution* is quite independent of the potential of any part of

this system as referred to the earth. In fact the entire system may be insulated from earth and given a static charge to thousands of volts and operate just as before.

If now we join any single point to earth, as at Q, that *point* acquires earth or zero potential. Assuming a good conductor between Q and A, the latter point will likewise be at zero potential and P will differ from Q by 140 volts, while B will be 220 volts

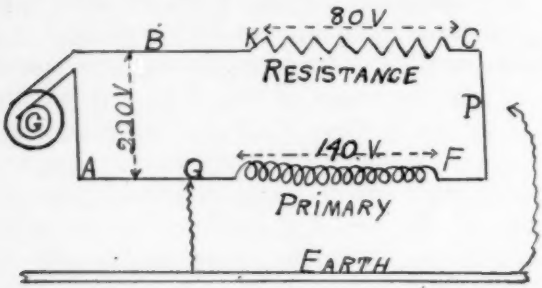

FIG. 1. EFFECT OF "GROUNDING" ONE SIDE OF THE PRIMARY CIRCUIT OPERATING AN *X*-RAY TRANSFORMER THROUGH RESISTANCE.
Potential difference between earth and line G to K, 220 V.
Potential drop in resistance 80 volts.
Potential difference between lines C, F and earth, 140 V.
Fall in potential through primary, 140 volts. Grounding another point, as P, may seriously disturb electrical conditions, depending on the resistance of path PEQ.

above or below zero. Grounding a second point, say at P between F and C, will tend to divert current from the primary to the earth, thence to Q. The amount of current so diverted will depend on the resistance over the path PEQ as compared to that of the primary. Contact between K and B would cause more current through the body than contact at P.

Now if there is no *ground* on the circuit one would get no shock by contact with either Q or P. But if one point, as Q, is "grounded" and one point of the body is "grounded," contact at P will allow current to flow through the body to earth and thence to Q.

The reader should note that these "grounds" may or may not allow any considerable current to pass depending on the resistance of the path PEQ and on the voltage between these points. In the case shown but little current could pass through a human body, as the resistance would be too great for the potential available. Observe that two contacts are needed; both may be direct to the circuit, or one may be indirectly made through the earth. So that a "ground" may make it easier to get a shock.

When we deal with much higher voltages the principles remain the same, but it becomes possible to force currents over much greater resistances and one does not need so low a resistance between the active line and the earth to have an effectual "ground."

Fig. 2 shows the electrical features of a transformer circuit where the middle of the secondary is connected to the case or is, for high potential purposes, "grounded" even though no conducting wire runs to "earth." Assuming operation at 60 K. V., i.e., at a little more than a 5 inch gap, the center of the

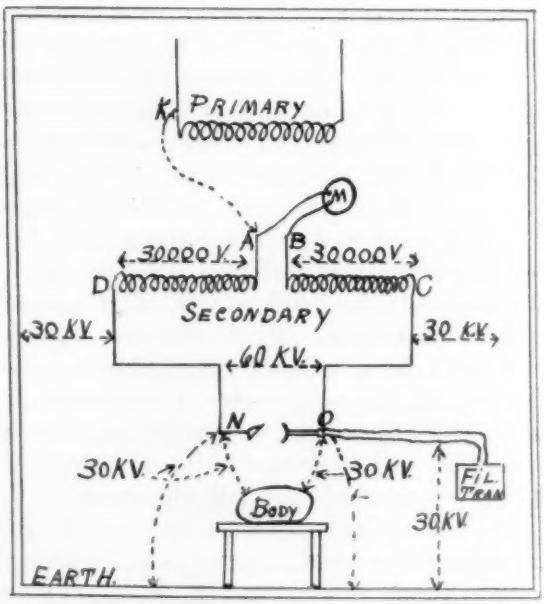

FIG. 2. ELECTRICAL SYSTEM 60 K.V. OPERATION. A AND B MAY BE CONNECTED TO A MILLIAMMETER, OR JUST CONNECTED TOGETHER BY A WIRE. A and B may be regarded for our purpose as having zero or earth potential. If the table is a conductor and is grounded, the patient's body becomes of earth potential. If body is insulated for several thousand volts, the nearest region of earth potential will not be the patient's body. *Note that when the body is between a conductor and the tube or line, danger is increased by grounding either the body or the conductor.*

secondary will be substantially at earth potential, each terminal will differ in potential from earth by 30 K.V. Thus if a pointed conductor connected to earth were brought about 2½ inches from either terminal there would result a discharge to earth. Current passing from C through earth back to B. While one would be quite safe in touching the point B, or a milliammeter connected as shown, there would be grave danger in a simple direct contact with a terminal or even in approaching close enough for a spark from either terminal or the line, although only *half* of the available voltage is involved. The advantage of this construction is that there is never more than *one half* the working tube voltage tending to cause discharge to the earth or anything connected therewith.

Sometimes in outfits designed to operate on *low* gap one terminal or line of the high tension is grounded. This makes contact by operator or patient with that terminal or line entirely safe; but there is twice as great a risk of spark-over from the other terminal as there is in the case of a grounded middle working at the same gap. One may also connect *one* point on the primary circuit to *one* on the secondary without any increase in danger. When this is done no *low resistance ground* is permissible from either primary or secondary. Serious damage to apparatus has resulted when such a second ground has been made; in fact all ground connections for apparatus protection are best made through suitable resistances.

Consider now a human body between two conductors whose potential difference exceeds a safe limit. If there is an adequate additional resistance or insulator between the body and both or one of these conductors there is no danger. Thus in moderately high tension power work, rubber gloves, insulating mats or platforms, oil switches, etc., are utilized to *insulate* the attendants. If both patient and operator were perfectly insulated from earth there would be no danger from contact with *one* side of a high tension circuit, or if sufficient insulating resistance were placed between them and *one* line they could not be injured by contact with the other side or line. Thus complete insulation of patient and operator from all parts of the high tension lines would be ideal if it could be done without interfering with the work. But no possible system that permits contact with or proximity to a high potential can be made entirely safe.

Assume now, as is usually the case, that the operator concerned is grounded. He must then ensure that no part of his body comes within sparking distance of any part of the high tension line.

In fact there should be a considerable factor of safety, so that the insulation between the body of operator or patient and any point on the high tension circuit ought not to be less than that of an air gap of twice the spark length of a discharge from the high tension line to a pointed conductor connected to the earth.

Thus when using a 9 inch gap on a transformer with a secondary grounded at the middle the shortest distance from the body to the nearest point of the circuit should not be *less* than nine inches. A much greater distance is desirable and except in deep therapy there is no reason why it should not always exceed double the sparking distance to earth.

We now need to consider the danger to the patient more in detail. Were the patient placed on a perfect insulator and *also* prevented from getting dangerously near both lines on opposite sides of the tube at the same time, he would be electrically safe. But when placed on a *grounded conducting table danger is greatly increased,* quite contrary to traditional belief. This may be seen from Fig. 2. The path of least resistance from either terminal to earth is from the terminal to the body, thence to the metal table. It makes no difference whether the tube stand is grounded as well as the table or not in so far as danger of electrocution is concerned, since the tube terminals are insulated from the stand in all cases. Also we may call attention to the fact that for high tension work

the resistance of the body may be regarded as negligible in comparison with that of a small air gap.

Hence safety of the patient when in contact with any conducting body and between this conductor and any portion of the high tension line is only insured by suitable insulation *between* the line and the patient. Grounding such a conductor, so that discharge from the line to earth would have *least resistance by passing through* the body, increases danger. The use of any metallic table for radiography or treatment where the patient is between the tube and the table should be prohibited. It should, however, be observed that when a horizontal or vertical fluoroscope is used the patient is *not between* the *high tension* and the metal and no danger to the patient arises from grounding.

Keeping in mind the above principles, one may ask: How are they to be applied, or in what particulars are present installations dangerous? One way to answer these questions would be to point out how a laboratory might be arranged so as to reduce the possibilities of danger.

First one must condemn the relegation of *x*-ray work to cellars, closets or dark and damp quarters where no one has a right to ask operators or patients to risk their lives in operating high tension apparatus. A considerable number of hospitals are open to just criticism in this respect. Also one must unqualifiedly condemn the crowding of apparatus into inadequate space. The room in which Dr. Jaugeas met his death was reported some months earlier as containing so many odds and ends of apparatus as to make it hardly possible to move about. Rooms to be used for radiography or therapy should be well lighted, dry, well ventilated and not overcrowded.

The present custom in American laboratories of using a large transformer for all work and running high tension lines from one room into another is a continuous menace, as it is always possible for one to attempt to make connections when the line is alive. The practice of having the operating switch board in a separate room at some distance from the tube stand and often having only a small window for observation is a great risk. There have been several cases of severe shock to roentgenologists or assistants when someone entered the booth or separate room and closed the switch without observing that the other party was adjusting the tube or that the patient had moved to a point of danger. There should be no possibility of closing the switch without standing facing the tube and with a clear, unobstructed view of the entire high tension system. The writer would advise a spring floor switch in series with the timer or operating switch, so that the operator must stand in one position in order to close the circuit, and in case of accident removing the foot would open the circuit irrespective of the timer. This would correspond to the "dead man's" button on electric cars.

Fluoroscopy can now be done with self-rectifying tubes and small transformers, avoiding all risk of having several connections to the same machine, as well as all expensive and complicated over-head systems. In a fluoroscopic room, since operation in darkness is essential, all high tension lines should be so protected as to preclude the possibility of any person, whether familiar with the apparatus or not, coming within ten inches of any part of the high tension circuit. The handles controlling the diaphragm should be of good insulating material and mounted so as to avoid proximity to the high tension line. A red light in shunt with the foot switch and in series with a line switch may serve two purposes: it indicates danger by showing that the main switch is closed, and also serves for weak room illumination when the foot switch is open. If both a horizontal and a vertical fluoroscope are to be operated by a single transformer, changes in connection from one to the other should be made by an oil-immersed switch of proper design. This will eliminate corona and needless exposure of the high tension circuit.

There should be no radiography or therapy using a metal table with the tube above

the table, quite irrespective of whether the stand is attached to the table or not. This means the use of a table top of insulating material with ample insulating supports between it and the metal frame or support.

The overhead high tension system should be of tubing (this may be brass instead of copper) firmly mounted in insulating supports. These tubes should extend to the transformer terminals. No part of the overhead should be less than seven feet from the floor and *only one set of reels should be attached*. No wires or other conductors should be suspended above or below the overhead system, or so that they may swing near to it. *Coolidge filament* wires are part of the high tension circuit and must be treated as such. Reels should be of substantial construction and mounted so as to preclude any possibility of their falling. Any reel permitting a sagging wire should be discarded or repaired at once. The wire on reels is often unsatisfactory, it should be stronger and ought to be inspected frequently.

When treating or radiographing nervous patients, children or those not likely to understand instructions, a sheet of strong canvas should be passed over the patient and fastened to the table so limiting movement as to prevent the patient from contact with line or tube by raising his arms or legs or by suddenly rising from the table. There is room for improvement in tube holders and terminal connections to assist in this matter. But even if this is done care must still be exercised, especially in deep therapy. The writer questions the advisability of deep therapy at as close a range as 8 inches. The terminals are as close as the target or may even be closer to the body. Further the ratio of deep dose-to-skin dose is much improved by working at greater target skin distance. Special terminals, such as described by Johnson, would help if not too cumbersome. A special screen might be developed if desired.

A quick acting circuit breaker should be inserted in the primary of *every* *x*-ray transformer. This should be set to act on not more than a 20 per cent overload. Thus if normal operation uses 35 amperes, then 42 amperes should open the breaker. Since on normal operation with a properly designed transformer nearly one milliampere tube current is secured for one ampere of primary current, it is not difficult to set a breaker for the largest current permitted. A short circuit through the body or otherwise would cause a primary current much above normal, thus opening the breaker.

Do not depend on line fuses. It takes time to raise a fuse to the melting point and delay is dangerous. They often stand a high overload for a long period without rupture.

If a double scale milliammeter is used it should be provided with an insulating device for changing the scale.

No complicated apparatus that will allow the terminals of the tube or the lines leading thereto to come near the patient or near to anything in contact with the patient should be permitted.

All switches should be self opening, requiring the operator to *hold them closed throughout an exposure, or treatment.* This should be done even though a time switch is used. Foot switches should not be constructed so as to lock or stick, but should open quickly and positively on release of pressure. Power switches should open down so that it would not be possible for them to fall shut.

Do not assume that a small outfit is essentially safe. One may be electrocuted by a small transformer if conditions are favorable, and he surely could be no more than killed on a large machine.

The rapidly increasing use of small transformer outfits with self-rectifying tubes for dental and bedside work demands special attention. There is danger from too close proximity to the lead wires, especially where both wires come near the patient or where one is near the patient and the other near metal, as in a metallic chair or metal bed. Also such outfits should never be operated by means of a foot switch. In two instances already reported to the writer an operator has been seriously shocked by some one acci-

dentally stepping on such a switch. Connections of the high tension wires to the tube should be substantial and certain. If one should become detached, unhooked or broken, it may put the patient in series with the tube, causing an unfortunate shock if nothing worse.

It must not be assumed that safety is *insured* by any *system of grounds* or special make of apparatus. In this connection the writer may call attention to the implication in the editorial section of the March issue of this JOURNAL that the American type of transformer is more dangerous because the "secondary high tension wires are in direct connection with the primary current through the transformer." As stated above there is *not* usually a direct or metallic connection between primary and secondary, and in any case the construction serves to avoid a potential to ground of more than one half of that operating the tube—a matter of considerable importance when operating at high gap as in deep therapy.

Ill advised grounding of electric power circuits may also cause a great deal of trouble and damage. The grounding of ordinary electric appliances such as transformer cases, conduits, panel board boxes, etc., has been worked out on the basis of long experience and is used to reduce risk in case of breakdown of insulation, accidental crossing of high and low tension wires, etc. Also where dampness or unusual conducting conditions are encountered lamp sockets and fixtures of special design are used further to protect the user and reduce fire risk. It is not permitted to ground a point on the active circuit except under very explicit conditions, since a second ground may be very dangerous. It follows that it is not wise to ground in the usual sense the case of an *x*-ray transformer. When it is done it should be through a suitable non-inductive resistance which will carry off surge or "static" without endangering the installation.

Aside from grounding for the real or supposed protection of the patient from discharge likely to endanger life, we have to consider the so-called static that often scares patients and troubles operators although not essentially dangerous. Whenever a high tension line is operated near insulated conducting bodies, such as metal plates, wires or the human body when on an insulating support, there will develop electric charges on these surfaces. The amount will depend on the area and proximity of the conductor, on the voltage of the line and somewhat on atmospheric conditions and the dryness of the walls and surfaces. When a person joined through more or less resistance to the earth, as the operator always is, approaches such a conductor, as for example the body of the patient, a brief spark discharge occurs. This is not painful or dangerous but tends to scare the patient and to suggest electrocution, *x*-ray burn, etc. It rarely occurs in radiography, but may be troublesome in treatment and fluoroscopy. In the latter it may be avoided by grounding the table if conducting, since the body is not between the tube and a grounded support. If trouble of this kind occurs in treatment it may be overcome by discharging the body through a pointed conductor connected to earth and brought near the body *after the operating switch has been opened*. There is rarely any difficulty of this kind in treatment, however, except where sheets of metal are used for protection and are so placed as to discharge to the skin, and this may be avoided by using felt or rubber between metal and skin.

There is an impression current among many that auto-transformer operation is essentially more dangerous than with resistance control. As is often true in other cases, a categorical statement of this kind cannot cover the facts. Keeping in mind that electrocution or serious injury may result from improper use with either control, there are two essential points to consider. When a tube is in operation at a given voltage the danger of spark-over to the patient is the same for both types of control, all conditions being alike. If an actual discharge to the body occurs the auto-transformer will maintain a larger current, and in that respect

be more dangerous; but the smaller current with the rheostat control may cause death or serious injury. Also when a circuit breaker is used it is likely to open much quicker with auto-transformer control than with rheostat, in part, at least, offsetting increased current by decreased duration. Even a moderate series resistance will delay the opening of a breaker somewhat.

In one important particular the rheostat control is much more dangerous than the autotransformer. Suppose a tube taking say 40 ma. at a 5 inch gap suddenly ceases to take current (a cranky gas tube, or a failure in the filament circuit on a Coolidge tube), with a rheostat control *the open circuit* or no current gap on this setting may be 10 or 12 inches, while with the autotransformer the difference between the 40 ma. and the no-current voltage may not exceed an inch. So that the danger of *starting* an arc by tube failure is much greater with the rheostat than with the other control, even though when once started the rheostat may be somewhat less dangerous because of lower current. This is of special importance when using a self-rectifying tube. The voltage of the suppressed wave will be very high on resistance control; hence an auto-transformer with a good circuit breaker is much safer with these tubes than is a rheostat.

Neither the precautions here mentioned nor indeed any formulation of rules or regulations can ensure safety to those concerned. But if they are followed they may help to avoid risk especially to those not familiar with the outfit who may be either patients or assistants. Nothing can relieve the roentgenologist in charge from the duty of knowing that reasonable precautions are taken and that every effort is exerted to secure protection. Neither are hospital authorities free from responsibility. They should not turn over equipment with such possibilities of danger to untrained people or accept advice only from those whose interest is exclusively in sales of apparatus.

Finally, medical colleges may some day come to realize that special training is needed for those who are to utilize such powerful agencies in their profession. It is quite true that there is not time to train all medical practitioners in all topics, but there should be provided opportunity for those who do specialize in radiology to secure adequate training. When this is accomplished this practice should be restricted to medical graduates who have, in *addition* to the regular medical course, such special training as is needed to increase both the usefulness of this agent and the safety of all concerned.

NOTE: The leaflet quoted in the March JOURNAL issued by Messrs. Watson & Sons may be questioned in some important particulars at least as applied to American laboratories. The matter of grounding has been discussed above, so that paragraph 1 may be passed. All will agree with 2, 4, 10, 11, 13 and 14. The advice given in 3 is dangerous, as the rate of insulation deterioration leading to breakdown is often high and a feeling of false security is encouraged by *assuming* that such insulation protects.

As regards 5 there should never be any *high tension overhead wires.* The writer pointed out some years ago the great advantage of metal tubes. These should be mounted with care and well braced and should extend clear to the transformer terminals. The idea of stretched grounded wires below the overhead would not only be cumbersome but would fail by breaking when an arc results from contact, and would short-circuit the transformer—a very dangerous procedure.

Paragraph 7 is surely bad advice. The writer had occasion a few years ago to test hundreds of fuses. They will often carry an overload of 100 or 200 per cent for some time before blowing and sometimes not blow at all. A quick acting circuit breaker is infinitely better.

In reference to paragraph 8, why are the metal terminals of the *Coolidge* tube assumed to be any closer to the patient or more dangerous than those of any other tube when operated at the same control setting? As regards metallic gauze one may cite an instance in France where one of our grounding enthusiasts used a wet sheet over a patient with quite unexpected results.

RADIUM THERAPY*

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NEW ORLEANS, LOUISIANA

AS a surgeon and clinician, I am unavoidably and deeply concerned in the practical application of radium and in comparing its effects in the treatment of surgical diseases which, until recently, have been regarded as the undivided province of surgery. To this end, I have availed myself of every opportunity for observation in every case in which radium seemed to be indicated. I have endeavored to do so with an open mind, without prejudice, and without allowing my judgment to be influenced by preconceived ideas. I have enjoyed very fair opportunities for observation in the last five years, and particularly in the last four, since the organization of the Radium Institute at the Touro Infirmary has given us greater technical facilities with a fair supply of the radium material. In all, over 245 patients, suffering from various surgical diseases amenable to radium, have come under my personal care and supervision, with the valued cooperation of the radiologist of the institute, Dr. Samuels, and his associate, Dr. Bowie. As a result of this experience, I have been impressed with some facts, and have arrived at conclusions which in some instances amount to convictions. I should also add that my experience is limited to the radium salts and not to its emanations, as we have not yet established an emanation plant, though the directors of the Institute are so well impressed with the results obtained by emanation that we are seriously considering such a plant as a necessary addition to our resources. Lacking in this experience, we have been deprived of one of the most valuable methods of bringing the diseased tissue under the influence of radium and for this reason should be most cautious in basing our conclusions on the ordinary surface or interstitial methods of applying the element.

We have learned a great deal about radium and the radioactive substitutes in the last few years; but our knowledge of its therapeutic powers is still in a formative stage. The universal interest felt in radium and the vast sums that have been invested in this country alone to develop its clinical uses, as well as the great industrial impetus given to its production to meet the growing demand, are the best proof of the profound impression that radium therapy has made upon the leaders of the profession in the most active surgical centers. When we consider that only ten years ago radium as a practical therapeutic agent was regarded merely as a scientific curiosity, and, that in spite of all the demonstrations and eloquent pleading of Robert Abbe, he remained for nearly ten years its solitary champion and pioneer apostle in this country, the contrast with the present almost feverish ambition of every important clinic in this country to acquire radium is perhaps the best tribute that can be paid to its worth and efficiency.

It is, in fact, only now that we surgeons have come to realize that radium has become not only a powerful ally, but an actual rival of surgery, and that radium, when skillfully and judiciously applied, will often yield extraordinary cures where surgery often fails.

It is no longer a question whether radium is to be applied, for instance, in inoperable cancer, and only after surgery has failed, but whether it should not be given the preference at the start as the initial and only treatment. It is quite natural that at the present time many, if not the majority of surgeons are reluctant to surrender to the new therapy some of their choicest and most dearly conquered possessions. It is also evident in the present state of our knowledge, that radium

*Summary of an address delivered by invitation at the Fifth Annual Meeting of THE AMERICAN RADIUM SOCIETY, New Orleans, La., April 26, 1920.

cannot cope with the great mass of the visceral cancers and other internal neoplastic diseases which are practically, if not absolutely, inaccessible to its action. On the other hand, it is quite clearly proven that whenever and wherever the morbid tissues can be brought fairly within the sphere of its influence, it can accomplish cures which are equal, if not superior, to those of surgery without any of its risks or fatalities. To arrive at conclusions in an absolutely fair and unprejudiced way is not always easy, as the interpretation of facts is so deeply influenced by the inclination and training of the observer. The pure technician and laboratory expert is likely to be too enthusiastic over the potentialities of radium; the surgeon, whose long training and skill have given him confidence in the outcome of his operations, is only too likely to depreciate its real value and to circumscribe its application by too many restrictions.

To attempt to cover all the conditions in which radium has been applied in our clinics either primarily, as the sole curative agent, or secondarily, as an adjuvant to surgery, would be impossible on this occasion. This can only be done in a detailed report of our work which is now in preparation. At this moment I can only touch in a cursory way upon some of the conditions in which my personal experience is sufficient to justify some conclusions.

In the first place, the angiomata or vascular tumors claim attention among the neoplastic diseases which have distinctly benefited by radium therapy. Practically all the members of this group, whether capillary, venous, cavernous, or erectile, and mixed, are more or less benefited by radium. But it is in the nevi or birth marks—"claret" and "port wine" spots—that spoil so many pretty faces by appearing in ugly patches in the most conspicuous parts (lids, lips, nose and cheeks), that radium displays its greatest curative powers. In dealing with the pure capillary nevi, or the coarser angiomata of a mixed type, when these appear on the face and neck, I believe that radium is entitled to the first consideration as the simplest, safest, and most efficient of our therapeutic agents. It is the only treatment that is effective without leaving a trace of disfigurement. The best results are obtained in new-born infants and in the younger children; in some instances the effect has been marvellous in the rapidity with which it has wiped out the blemish without leaving a trace of its action. In older patients the treatment is longer and less brilliant than in infants and young children. While radium must be regarded as the sovereign remedy for this class of angiomata, it sometimes fails, and we should be prepared for disappointments. I have now in mind a young woman of twenty-five years, who has a capillary nevus of a "port wine" color, which overspreads half her face like a mask. We have treated this girl systematically at different times for the past eight months by the method of divided and alternate squares which Wickham and Degrais so successfully practiced twenty years ago. In spite of this and at times more intensive treatment, to the extent of causing a superficial burn, the nevus has remained unaltered. The dosage of the radium and the method of application being the same as in the successful cases, the failure in this particular case can only be accounted for by an inherent resistance of the tissues, a hyporadio sensibility or apparent immunity to the action of the radium rays. It is this peculiarity of certain individuals, which manifests itself in other tissues and in other ways, apart from the angiomata (fibroids, cancer, etc.), as we see in the different reaction of certain individuals to sunburn and other effects of the sun's rays, that makes it impossible to predicate with absolute certainty what the result of an initial radium application will be in any given case. Fortunately these experiences are exceptional and do not affect our general valuation of radium as a therapeutic agent, any more than of other valuable remedies which are known to vary in their action according to individual idiosyncrasies.

Another and more important group of tumors which is especially conspicuous as a beneficiary of radium therapy, is that consti-

tuted by the uterine fibroids and fibromyomata. Here radium has cut down my operations for this cause by over 60 per cent. In the last four years I have treated 63 uterine fibroids with radium, and with the exception of four cases, all have been treated exclusively and successfully by this agent. In three cases, hysteromyomectomy had to be performed on account of the secondary necrotic degeneration of the tumor mass following the intensive action of radium. In another case, owing to the great mechanical difficulty in applying the radium into the uterine canal, roentgentherapy has been substituted after several applications, which, however, had succeeded in supressing the menstrual flow. This patient is still under observation, though free from complaints. All the others have recovered, or, at least, are symptomatically cured. The best results have been obtained in the soft, rapidly growing intramural myomas. The effect of radium upon some of these masses is sometimes marvellous. The bleeding stops and the tissues undergo a rapid atrophic change in an astonishingly short time. Some of these tumors, of such large size that they reach to the umbilicus and fill the pelvis, show by their rapid diminution that the action of radium is exercised primarily upon the vascular supply of the uterus, and that the atrophy is due to the ischemia induced by the degeneration and blocking effect on the uterine circulation. But it is this very effect that compels the greatest caution in the application of the initial doses. An overdose of radium may bring about a rapid necrosis of the mass which is followed by toxic phenomena from the too rapid absorption of the dead tissues. The larger the growth the more cautious should we be in our initial treatment. In cases where a febrile reaction occurs, with nausea and vomiting, and other evidences of toxic absorption, these phenomena are not caused by bacterial infection, but are simply significant of a toxemia from pure necrotic absorption. It is surprising to observe how nature succeeds in eliminating these large dead or dying masses. I have in mind a recent experience in which the patient was rendered extremely anemic and weak from profuse and intractable hemorrhages caused by a very large and rapidly growing fibromyoma (about the size of a five months' pregnancy). The hemorrhage was very profuse and we were compelled to use 100 milligrams for 12 hours, repeatedly, before it could be checked. When this was arrested, chills and fever developed—103° and 104°, followed by quotidian intermittencies for over a week. This patient had been in a malarial district, and we thought the chills might be of malarial origin, but the blood showed no evidence of plasmodia. There was no marked leucocytosis. She was given quinine, however, and just as I had decided to operate the fever gradually subsided. The changes in the uterus following the arrest of the hemorrhage, and just as the febrile movement had begun, were extraordinary. The uterus became turgid, swollen, and edematous, and the cervix elongated until it almost projected from the vagina, and a profuse mucoserous drainage flowed from the external os. The local effect was very much like that which would follow the sting of a venomous reptile. With the subsidence of the fever, the local edema and swelling of the uterine tumor also subsided, and, when the patient came back to see me two months later, the uterus had been reduced to the size of a pear, it was normal in size, mobility, and position, and the general improvement was such that the patient was scarcely recognizable.

With increasing experience and better technic, these violent reactions which were very alarming in the earlier cases, have notably diminished, though a mild type of "radium sickness" (low temperature, nausea, bad taste, and general myalgias, etc.) still remain at times as evidence of necrobiosis and excessive dosage.

In the selection of cases, we have found that the multiple subperitoneal and pediculated fibroids, and the very hard, sclerotic, and partially calcified fibroids, are the least influenced by radium; the intramural and

submucous fibroids are most amenable to its action. Radium is never applied to cases of doubtful diagnosis or when complicated by pelvic infection in any form, with ovarian cysts, or other abdominal lesions which can only be relieved by surgical treatment. In all profoundly anemic patients, who have been exhausted by profuse and prolonged hemorrhages, radium is always applied for the hemostatic action which it exercises on the endometrium, regardless of the cause of the metrorrhagia. Probably the greatest benefit from radium has come to that class of patients who, rendered profoundly anemic and exhausted by bleeding fibroids, are unfit for surgical relief on account of complicating diseases, such as chronic or acute nephritis, advanced cardiac or pulmonary lesions, hyperthyroidism, etc. I do not believe that the mere size of the tumor is a contraindication to radium, provided it is an intramural growth of the soft, rapidly growing, bleeding type in which the uterine canal is elongated sufficiently to allow the radium to be deposited in its interior.

The relation of the cure of fibroids by radium to menstruation, the premature menopause and sterility, is still a controverted question. Is it necessary that the menstrual function should be permanently arrested and that the premature menopause should be brought about to cure the fibroids? Without attempting any generalization, but merely as a bald fact, I would state that thus far I have treated 78 cases of metrorrhagia with radium. Of these 64 were caused by fibromyomata and 14 were of the so-called "essential" type (non-neoplastic). The majority were married women, and the greater proportion were within the reproductive age. Thus far in no case has conception occurred, at least during the last four years. This includes patients who have been treated in the last six months. It would, therefore, be altogether premature to arrive at any conclusions apart from the mere statement of the gross fact. On one point I entertain a definite conviction, and that is that no uterine fibromyoma of sufficient size to be easily palpated and to cause symptoms and especially metrorrhagia, can be cured in any permanent sense without bringing about a total suppression of the menstrual function—in other words, by inducing the atrophic and involution changes of the menopause. As long as the flow continues with regular or irregular periodicity, and no matter how scant, the growth of the tumor is not under control. It is only when the menses are completely arrested that we have the first assurance of the effectiveness of the radium treatment.

In dealing with the metrorrhagias of puberty, so-called, of the menopause, or of the middle period, for which granular metritis or other endometrial pathology is responsible, radium is the sovereign remedy when all the classical treatments have failed. In these I believe it is possible to bring about, by proper radium dosage, a complete amenorrhea without necessarily inducing the ovarian changes of the artificial climateric. In these, a return of the normal menses with the preservation of the ovarian function may, and no doubt does, occur. But in my experience the cases of metrorrhagia requiring radium to check them have been so severe that the dosage required has been as intensive and prolonged as that which I have used to induce atrophic changes in fibroids. In consequence, the radium amenorrhea has been permanent in every case, though it is possible that in the younger women there may be a return of the flow in spite of the lapse of two and three years.

One observation I feel confident will be borne out by future experience, and that is that as long as the radium amenorrhea lasts there will be no conception. Whether the sterility caused by radium is due to degenerative changes in the uterus or in the ovary, or both, I am not prepared to discuss; but it is my belief that radium applied to the uterus in the usual way exercises its influence chiefly and primarily, if not solely, through its local effect on the uterine circulation, and that its radiations are more likely to spare the ovaries which are usually beyond the sphere of its direct action.

It is well known that the most eminent radiologists (M. Béclère, for instance) aim at the ovaries with *x*-ray radiations, with the intention of bringing about the cure of fibroids by the suppression of ovarian function. And yet it would seem much more difficult to spare the ovaries by roentgentherapy than by radium, in view of the difficulty, if not practical impossibility, of limiting the *x*-rays to definite, circumscribed areas, especially when the target aimed at (the ovaries) is in the dark, and its location—especially when uterine fibroids are the object of the treatment—is more than problematical. In this connection the recent communication of M. Ménard, radiologist of the Cochin Hospital, (Société de Chirurgie, Paris, Feb. 17, 1920) who reported three cases of pregnancy occurring in the course of the radiologic treatment of fibroids, is of unusual interest. M. Ménard reports these cases to prove that—contrary to M. Béclère's and the general belief—fibroids can be successfully treated by radiotherapy (*x*-rays) without interfering with conception or a normal pregnancy. In the firs tcase, the patient had been radiated eight times during the first month of gestation before pregnancy was discovered—in all she had been radiated fourteen times; in the second, eleven radiations during the first four months of gestation, eighteen times in all; and in the third, six radiations after pregnancy had occurred and thirty-five sittings in all. The first two had gone through a normal gestation and labor, with the birth of perfectly normal children; in the third, pregnancy was propressing normally in every way and she was expecting delivery when the report was published. In the first two cases, the patients were apparently normal when examined four years after their delivery. In the first case, the normal menses appeared six weeks after childbirth; in the second, five weeks after the confinement. The diagnosis and details as to the size and character of the fibroids are not given because M. Ménard, acting purely as a radiologist, had accepted the diagnosis made by a competent gynecologist. These are certainly extraordinary observations, and they are remarkable chiefly because of their exceptional and rare occurrence. Whatever their bearing upon the *x*-ray therapy of fibroids, they certainly cannot apply to radium which, by virtue alone of the intra-uterine application of the element, would surely interrupt the progress of a normal gestation.

Be this as it may, I believe that no one who has a fair opportunity for comparing the relative merits of roentgen with curietherapy will gainsay that radium is by far the more effective, certain and rapid of the two methods; and whoever has practiced with radium (in fibroids) will not go back to the *x*-rays except in very unusual circumstances or when radium is not available. I know that Béclère has recently reported 386 cures of uterine fibroids out of 400 cases, all cured by radiotherapy alone; but, without questioning his figures, I would only remind you that in spite of the fact that France is the birthplace of radium therapy, radium is scarce in France and has only come into gynecologic practice in very recent times; in fact, only since the war. But even now some of the most eminent French gynecologists (M. Faure, for instance) speak as if a new era had dawned in the treatment of fibroids since the introduction of radium. Personally I would express my conviction in regard to the superiority of radium, by saying, that in the case of one of my family, my wife, my daughter, or some one over whom I had authority, or for whom I felt a direct responsibility, I would unhesitatingly look to radium as my first choice. In the light of my surgical experience, I deem it safe to estimate the average mortality of uncomplicated hysteromyectomies at 4 per cent, even in the most skilled hands. But even if the mortality were reduced to 1 per cent, I would still deem it my duty to try radium first, as the easier, safer, and more benign mode of cure, and the one that would impose the least hardship on my patient. It is understood that I am speaking of uncomplicated fibroids of the recognized type for radium treatment.

So much time has been consumed in the discussion of the radium therapy of fibroids that little is left for the most important phase of the subject—the treatment of uterine cancer. My remarks will therefore be briefly limited to the impressions gathered from the study of 45 of the uterine patients who have come under my personal observation, exclusive of 77 malignant cases which have been treated in other organs or localities. The majority of these uterine cancers have involved the cervix, and a small proportion have represented the fundal type. The majority have been referred to me after recurrence following hysterectomy by other operators.

In my own practice the fundal cases have all been subjected to a total hysterectomy after a preliminary curettage and a single intensive radiation for prophylactic purposes, with the hope of preventing metastasis. These (5 cases) have all done well, though the period of probation has not exceeded a maximum of four years and a minimum of five months. I can only say in regard to one fundus case which came to me in an advanced septic state, with pyometra from atresia of the external os, and with complete fixation of the uterus and general parametrial infiltration, that the prolonged application of radium in large doses, 100 milligrams for twenty-four hours repeated at short intervals after a preliminary curettage, brought about a perfect symptomatic cure which has continued to the present time, or nearly four and a half years. In dealing with the cervical carcinomata in their incipiency, I preferred in earlier years to apply a heavy dose of radium for twenty-four hours and follow this by a total hysterectomy; but lately I have gradually come to depend upon radium exclusively, as the results seemed to me far better from the point of view of permanency of cure than in the advanced and inoperable cases. The number of these incipient cases treated exclusively by radium is yet too small and the time that has elapsed too short to assert a positive cure. However, I have now under observation five cases in which cervical carcinomata, demonstrated as such by histological examination, have remained symptomatically well for a minimum period of four months and a maximum of three years.

Judging by the usual symptomatic benefit obtained in some of the most hopeless cases that have come under my care after the failure (recurrence) of the most radical operations, it seems to me only logical to conclude that the chance of permanent cure by radium in incipient or early cases would be infinitely greater than in the advanced inoperable cases.

It is, again, my conviction that in cervical carcinoma, if radium is applied before metastasis has occurred, a cure will be obtained which is more certain in a permanent sense than can be obtained by surgery. In the advanced postoperative recurrences, metastasis has, as a rule, already occurred in regions which are entirely beyond the zone of radium influence. For this reason the brilliant results obtained in this group are only temporary and the vast majority ultimately die of cancer. In dealing with cancer, more so than with fibroids and other neoplastic tissues, it is a matter of common observation that whenever recurrence occurs after an apparent radium cure, the reapplication of the element appears to exercise little or no controlling influence. The neoplastic tissues appear then to have acquired a sort of immunity against radium which makes them absolutely refractory to all further treatment.

In other localities, as in the breast, where the metastases are generally external and visible, the pursuit of these with radium exerts a checking and controlling influence which is denied in the pelvic and in the visceral organs.

After reviewing my experience with carcinoma of the uterus, and especially of the cervix, I have come to the conclusion that the greatest hope of cure offered by radium lies in the primary application of this agent in the very earliest stage of the disease, when the neoplastic area is well defined and cir-

cumscribed, and before metastasis has occurred. Then we may reasonably expect a cure and not, as happens now, when radium is applied as a last resort after recurrence and wide dissemination have demonstrated the failure of the knife.

But even in these inoperable and recurrent cases the relief given by radium is, as all must admit, a blessing of incalculable good. Nothing in the long history of cancer therapeutics can compare with the splendor of its action in transforming a life of suffering and despair into one of relief, relative comfort and cheerfulness. But it is at this stage that we must be most cautious in our prognosis, and not allow ourselves to be caught in the general enthusiasm that follows this marvellous improvement that so often simulates a cure. The public should understand that in advanced recurrent and metastatic cancer these symptomatic cures are only of temporary duration and that, ultimately, the disease will assert itself and claim its victim. On the other hand, the relief obtained, which may continue for months and years, still gives to radium the supremacy over all palliative remedies in the treatment of uterine cancer.

[The stenographic report of this address has been revised and in many parts rewritten for publication, but without altering the meaning or purport of the verbal message. R. M.]

A NEW METHOD OF MOUNTING INTENSIFYING SCREENS

By ROBERT T. MORRISON

Eastman Kodak Company

ROCHESTER, NEW YORK

IN attaching screens to cassettes, a common practice is to apply a drop of glue at each corner and at several points along each edge, between the screen and the cover of the cassette. Most cassettes have a layer of felt interposed between the screen and the cover of the cassette, in which case the felt is glued to the metal cover and the screen in turn is glued to the felt. While this method is perhaps the most convenient for the average user, it has several objections.

The chief defect in the present method is the uneven screen surface which occurs in the regions where the glue has been applied. In the case where the screen is glued directly to the metal, the expansion of the screen may cause it to buckle between the spots where it is held by the glue. Where felt is used, small convex areas are formed on the screen surface by the spots of glue. Tests have shown that any unevenness in the screen surface results in impaired definition, due to the poor contact between the screen and the sensitized material. The loss of definition may be demonstrated by radiographing a wire screen placed on the cassette.

Glue is not fully satisfactory in that it does not permanently hold the screen in the cassette, especially where felt is used between the screen and the metal cover of the cassette. In addition, small particles often chip off from the hard dry glue and ultimately some of them reach the screen surface or surfaces where they either adhere to or scratch the delicate surface of the screen.

It has been suggested that screens might be mounted in cassettes with dry mounting tissue, which is used ordinarily with a hot iron or press for mounting photographic prints. To determine the feasibility of this method, especially in regard to overcoming the present faults, the following tests were made.

The first experiment was an attempt to mount an 8 by 10 screen on a flat aluminum plate of the same linear dimensions and 1/8 inch thick. Two layers of dry mounting tissue were inserted between the screen and the

plate and the whole placed in a dry mounting press, the heat being applied to the aluminum plate. The sensitive surface of the screen had been protected with a sheet of paper. In a few minutes after applying the heat, the screen was firmly attached to the plate over its entire area.

In another experiment the heat was applied to the intensifying screen surface instead of to the metal plate. The dry mounting press was cold to start with, and the heating current was turned on after the screen and metal plate had been clamped in position. By this method the screen was heated gradually, and the screen and plate were satisfactorily cemented together without any damage to the screen. However, subsequent experiments showed that the screen may be seriously damaged by applying the hot plate or iron directly to its sensitive surface; therefore such a procedure is not to be recommended.

Next, an attempt was made to mount the screen with felt between it and the metal plate. Dry mounting tissue was placed between the felt and the screen, and between the felt and the aluminum plate, and the whole inserted in the dry mounting press with the heat applied to the metal plate. The results were entirely satisfactory, the screen, felt and plate being firmly fastened together.

The next effort was to mount a screen in a cassette with an electric iron instead of the dry mounting press. Mounting the screen directly on the metal required a longer time with the electric iron, but the results were entirely satisfactory. Where felt was interposed between the screen and the metal, the method presented some difficulties because of the rapidity with which the heat was radiated from the metal cover of the cassette. The best results were obtained when only a number of spots, instead of the entire surface, were covered with tissue and the heat applied to them. In the case under consideration, i.e., using an 8 by 10 cassette, small pieces of tissue (double layer), about 1½ inches on a side, were placed in each corner and one in the center. By placing the iron over each area in succession for a sufficient length of time (about ten minutes), the desired result was obtained with felt between the screen and the cassette. This method is not practicable where the cassette cover is painted, since the heat required is sufficient to damage the paint. Screens mounted this way were easily removed by heating sufficiently and separating the two elements while still warm.

These tests show that the use of mounting tissue to cement screens in cassettes is practical, and overcomes some of the faults of the present method of mounting. There is a saving in time also, since the cassettes can be used as soon as they are cool, whereas if glue is used considerably longer time must elapse for the glue to dry.

In using this method precautions should be exercised to prevent damage to the screen. It is not safe to apply the heating element directly to the screen surface. If the temperature of the screen is increased gradually and uniformly over the surface, such as takes place when the heat is applied by an electric iron on the metal cover, the screen does not suffer any damage. The heating should be discontinued when the melting point of the tissue (approximately 140° F.) has been reached. This can be determined by an occasional observation made by slightly separating the screen from the support during the process. This method is perhaps more troublesome than the use of glue in attaching screens in cassettes, but it gives better results. It produces no unevenness in the screen surface, fastens the screen firmly to the cassette, and allows the screen to be readily removed when it is necessary to replace it.

This method was first suggested to us by Mr. Otto Doehn of Cleveland, to whom due acknowledgement is made.

A STEREOFLUOROSCOPE*

By STANTON HECK, M.D.

SALEM, OHIO

GRANTING that the Coolidge tube has made possible a practical stereofluoroscope, its absence from the roentgen laboratory of the average modern hospital is evidence that it has not yet reached a satisfactory form. To promote and hasten its development is the object of this paper.

You are all familiar with the theory of the stereofluoroscope first demonstrated by Mackenzie Davidson years ago. The instrument I am about to describe is yet far from perfect. We have in Fig. 1 a front elevation showing the relation between the tubes, screen and eye points. The anode screen distance is 20 inches, double the eye screen distance of 10 inches. The distance between the anodes is 5 inches, or double the pupillary distance of 2½ inches. This arrangement of having the anode screen distance greater than the eye screen distance and making the distance between the anodes bear a corresponding ratio to the pupillary distance, places the patient at a favorable point for operation or manipulation, and at the same time prevents unfavorable distortion or blurring of the image.

In support of this contention, some exposures are here presented of a cube of wood containing screws and tacks. Fig. A is a lateral exposure, showing the actual distance between objects. In the stereoscopic exposure the cube is placed 2 inches from the plate. The small lead oval is in contact with the plate. The images are so placed that when viewed by direct vision the pseudo-image is presented. This is the image seen in the stereofluoroscope. When viewed in the ordinary hand stereoscope the normal image is seen. When viewed at the same distance by either method the depth values remain the same. In Fig. B the anode plate distance is 12 inches, tube shift 2½ inches. When viewed at 12 inch depth, values are normal. The outline of objects is somewhat blurred. In Fig. C the anode plate distance is 36 inches, tube shift 2½ inches. When viewed at 12 inch depth values are much lessened. When viewed at 36 inch depth values become normal. Notice the sharp definition due to long tube-plate distance. In Fig. D the anode plate distance is 36 inches, tube shift 7½ inches. When viewed at 12 inch depth values are normal.

The side elevation shows the eye-point outside the cone of direct rays from the tube. This arrangement, while protecting the eyes and placing the observer in a comfortable position, does not seriously distort the image.

The shutter consists of two revolving discs 6½ inches in diameter. Their centers are 8 inches apart. A concentric strip ¾ inch wide is removed from somewhat less than half the circumference of each. When this space passes in front of the eye-hole of the face plate it allows the corresponding eye to see the screen, and at the same time the other eye is shut off by the intact portion of the circumference on the other disc. In front of the shutter is a metallic face-plate having openings corresponding to the position of the observer's eyes, and a depression in the center and below for the nose and mouth.

Fig. 2 shows a rotary switch, the moving part consisting of a shaft mounting a 12 inch arm. The shaft lies in the same plane and parallel with the shafts on which the shutter disks are mounted. The shutter disks and switch rotate in the same direction and at the same rate of speed through a suitable gear connection. An electric motor drives this system at a speed of 900 revolutions a minute, by a belt running over a pulley on the switch shaft. By this means the eye gets fifteen light impressions per second. The arm

*Read at Twentieth Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Saratoga Springs, N. Y., Sept. 3–6, 1919.

carries the high tension current, and its extremity travels close to two semi-circular rods, each of which is connected to one of the Coolidge tubes.

ameters, and in front the control rheostats.

Fig. 4 shows the table for the patient, which is mounted on castors. Its top is a canvas-covered stretcher. Each end of the

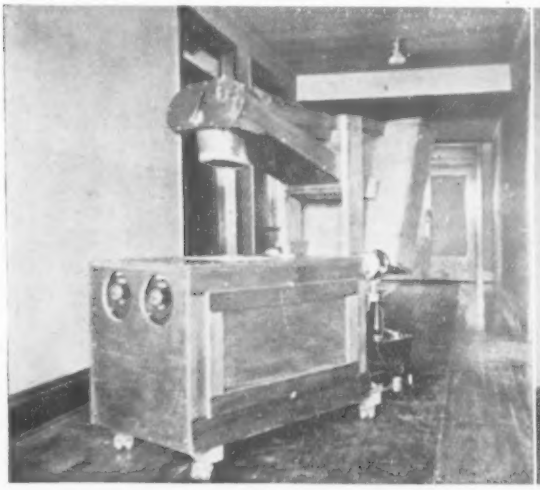


FIG. 1. DR. HECK'S STEREOSCOPIC FLUOROSCOPE. VIEW OF FRONT END AND RIGHT-HAND SIDE.

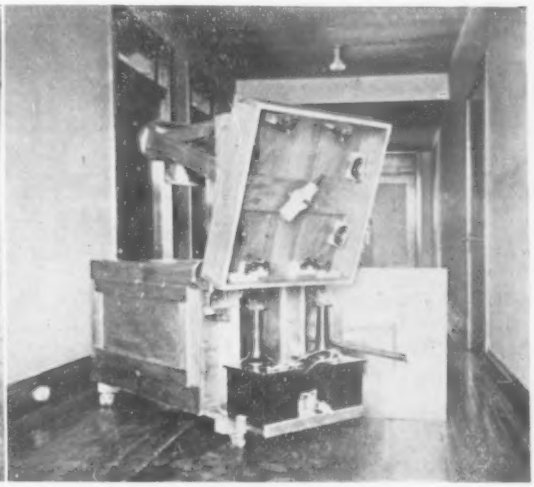


FIG. 2. VIEW OF REAR END, SHOWING ROTARY SWITCH. COVER REMOVED AND STANDING ON THE FLOOR.

FIG. 3. CLOSE-UP VIEW OF EYE-PIECE. Note depression for nose and mouth and that one shutter is open and the other closed.

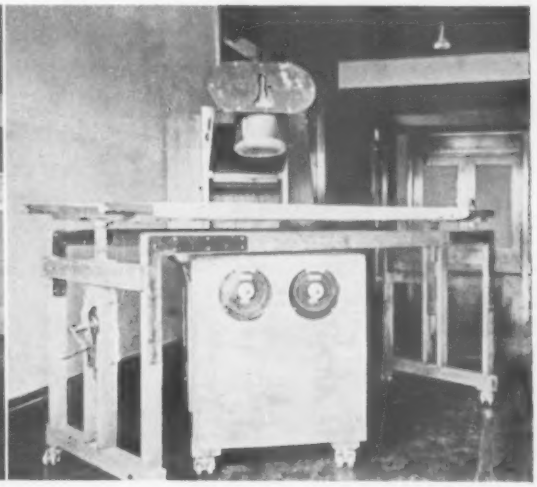


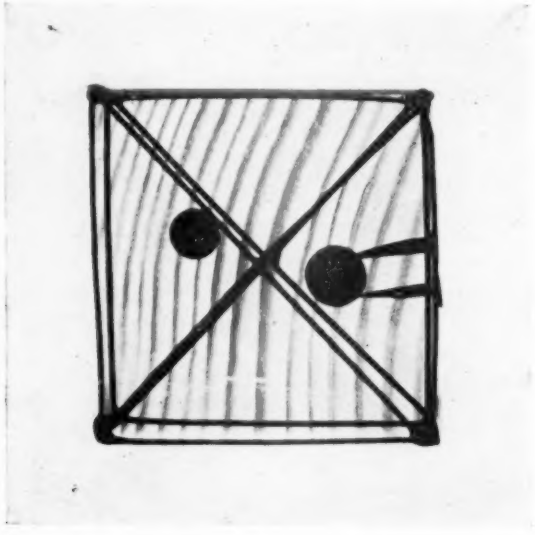
FIG. 4. SHOWING THE ADJUSTABLE STRETCHER IN POSITION.

Fig. 3 shows, on its upper portion, the screen and face plate with its nose depression and eye-holes. Behind is seen the Coolidge filament transformers and their milli-

stretcher rests on a support with 10 inches of vertical adjustment. This is accomplished by a rack engaging with a spiral pinion. In an earlier model than the present one, the shut-

ter and switch are on the same shaft, but the present contrivance amounts to the same thing.

In the development of this instrument, the writer is under obligations to many persons for suggestions and material assistance, especially to Dr. W. D. Coolidge, and to Mr. W. H. Mullins of Salem, Ohio.



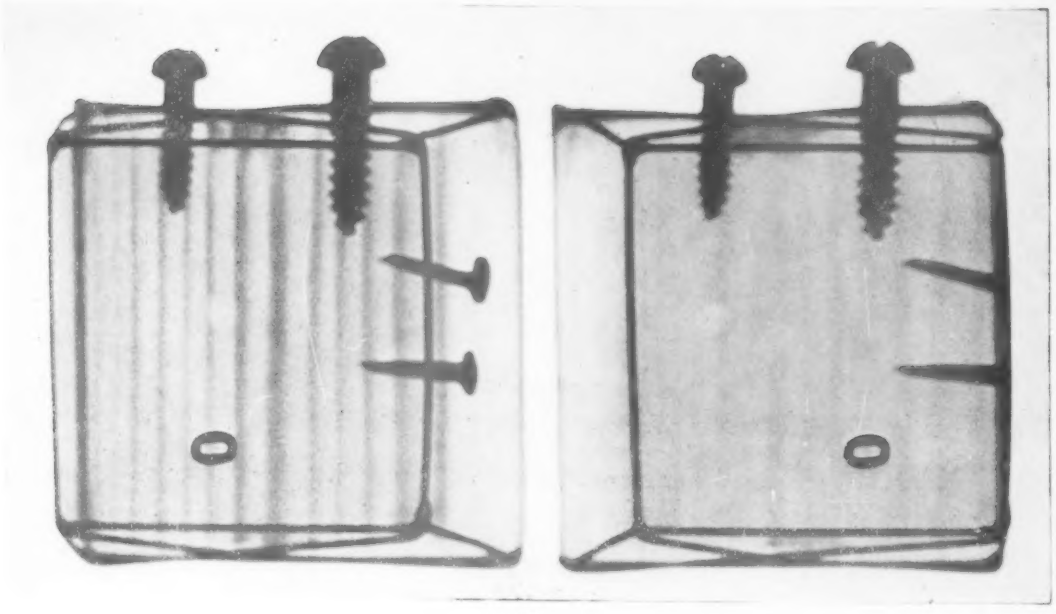
A

DISCUSSION

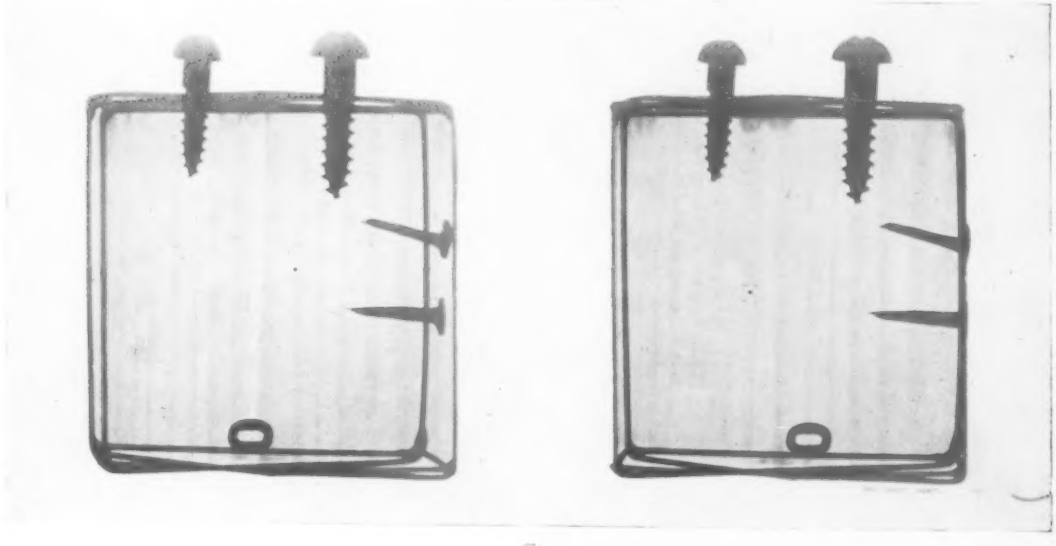
Dr. David R. Bowen.—The engaging thing about Dr. Heck's fluoroscope is that when one goes into his laboratory to see it, there is an entire absence of fuss and feathers. He just rolls it into the middle of the floor, hooks it up and then it works. Just what practical use he has been able to make of it I do not know; but Dr. Heck has displayed so much ingenuity and originality in working out the details of this apparatus that I do not believe any history of the stereoscopic fluoroscope can be considered complete unless it mentions this very interesting apparatus of Dr. Heck.

Dr. W. D. Coolidge.—I want to say a word by way of appreciation of Dr. Heck's work. I went to Salem to see his stereofluoroscopic apparatus and was very much impressed by it. I feel that in the future development of this method, we are, perhaps, more likely to use self-rectifying *x*-ray tubes and a single synchronous motor-driven shutter. But this much must be said of Dr. Heck's apparatus as it was when I saw it—it worked, it was brutally simple and it could not get out of synchronism.

I felt then, and still feel, that this apparatus was good enough as it stood to enable one to answer the question, which is apparently still unanswered, as to whether a mechanically and electrically perfect stereofluoroscope could or could not be usefully applied.



B



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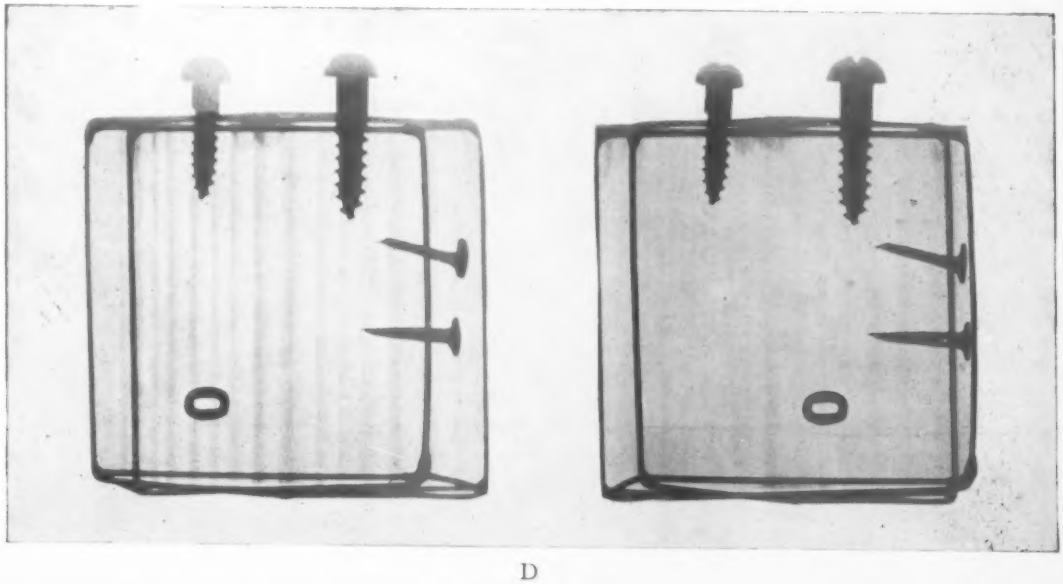

D

X-RAY STUDIES IN GOUT

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RADIOGRAPHIC studies of the hands and feet of gouty subjects have been made by Huber,[1] Drinberg,[2] Strangeways,[3] Jacobsohn [4] and others. With the exception of Huber and Strangeways all authors have considered certain radiographic findings to be pathognomonic evidence of gout. The present study was made for the purpose of attempting to determine whether the diagnosis of gout was justifiable upon the basis of the findings of these investigators. For this purpose the plates of the hands and feet of nine cases of tophaceous gout have been studied. The findings are given in the following protocols.

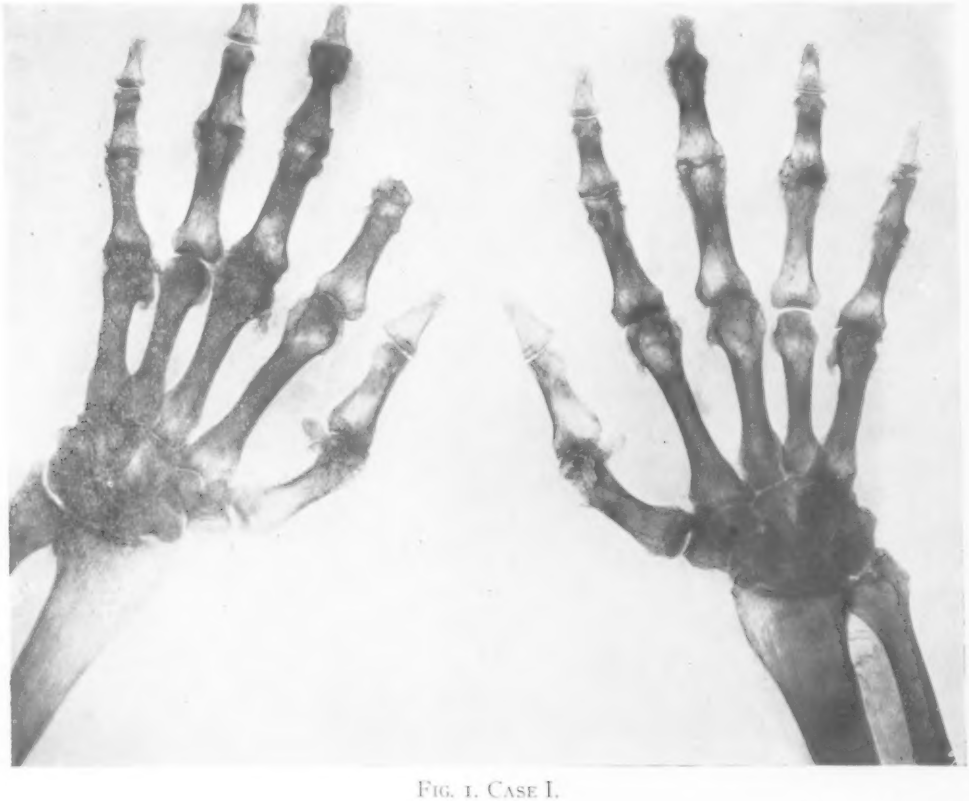

FIG. 1. CASE I.

CASE 1. J. G., Med. No. 5421. White, male, aged forty-three. Diagnosis: Gout; tophi; arteriosclerosis; hypertension; chronic myocarditis; very questionable chronic nephritis.

ROENTGEN REPORT NO. 8140

Hands and wrists: There is moderate bony atrophy of the lower ends of the radii, ulnae, all the bones of the carpi, metacarpi and phalanges. Proliferative changes involve most of the articular ends of the phalanges and of the distal ends of the metacarpals. The bones of the wrists show mottling, due to small areas of decreased and increased density. All the joint spaces of the wrists are narrowed and there is some irregularity in outline of the articular surfaces of the bones.

The heads of the metacarpal bones, except the fourth metacarpals, of both hands show spur formation and more or less mottling. The metacarpo-phalangeal articular surfaces of the bones are irregular in outline. The articular margins show variable degrees of increased density and the corresponding joint spaces are narrowed. These changes are most pronounced in the metacarpo-phalangeal joint of the right middle finger, the articular surfaces being completely destroyed and replaced by an irregular density. The metacarpo-phalangeal joint of the right ring finger is normal except for slight narrowing of the joint space. The interphalangeal joints present various degrees of the same processes. Some of the interphalangeal joints described in the metacarpo-phalangeal joints are normal in appearance. Others, especially the proximal interphalangeal joints of the fourth and fifth phalanges of the left hand, are more or less obliterated and replaced by deposits of increased density with proliferative changes (lipping and spur formation). The shaft of the middle phalanx of the middle finger of the right hand is narrowed. There are numerous, more or less circular, frequently fairly well defined focal areas of decreased density, localized mostly in the heads of the metacarpal and phalangeal bones.

The soft tissues of the fingers show irregular nodular thickenings. The larger arteries of the forearms and wrists are visible.

Fig. 2. Case I.

Feet: The plantar arches are high. There is a moderate amount of bony atrophy of all the bones of the feet. The tarsal bones present a mottled appearance due to small areas of alternating increased and decreased density. The tarsal joint spaces are narrowed; some of them are obliterated and replaced by irregular lines of increased density. All these changes are more pronounced in the left foot. The heads of both first

metatarsal bones are mottled. The margins of their phalangeal articular surfaces show lipping and the corresponding joint spaces are narrowed. The head of the second metatarsal bone of the right foot shows proliferative changes. The heads of both fifth metatarsal bones are irregular in outline. The articulating surfaces of the bones forming the metatarso-phalangeal joints of both fifth metatarsals are irregular in outline. be circular in outline, the borders are more or less well-defined and vary in diameter from one to five millimeters. The soft tissues in the regions of the first and fifth metatarso-phalangeal articulation of both feet show slight nodular thickening. The larger arteries of the feet are visible.

Summary of the radiographic findings: The changes found are atrophic, proliferative and destructive in type. Certain bones

Fig. 3. Case II.

There is partial subluxation of the bones of the fifth metatarso-phalangeal joint of the right foot. The rest of the metatarso-phalangeal joint spaces show varying degrees of narrowing. The interphalangeal joint spaces of the halluces are narrowed and there is lipping at the margins of the articular surfaces. Both great toes show a moderate degree of hallux valgus.

In the heads of both first, both fifth and the right second metatarsal bones are focal areas of decreased density. The latter tend to and their joint surfaces are involved in these changes while others are normal or nearly normal. Some of the joint spaces are obliterated and ankylosis has occurred in certain of them. There is partial subluxation of one joint. There are focal areas of decreased density in some of the bones. The regions in which these areas occur usually show other bony changes. Nodular thickening of the soft tissues and arteriosclerosis of the larger vessels are present.

Case 2. W. P. G. Med No. 5471. Negro,

male, aged forty-three. X-ray No. 8225. Diagnosis: Gout; tophi; questionable chronic nephritis.

ROENTGEN REPORT NO. 8225

Feet: In the examination of the feet all bones of both feet show slight bone atrophy. The right foot shows slight hallux valgus with narrowing and slight roughing of the first metatarso-phalangeal joint. The proximal phalanx of the right great toe shows increased density of the proximal end. The left metatarsal joint shows slight lipping of the base. In the head of the right first metatarsal bone and proximal phalynx of the great toe right cuboid, are circumscribed, punched-out areas of decreased density, the first metatarso-phalangeal joint being involved. The head of the left first metatarsal bone presents an area of decreased density, the borders of which are diffuse.

In the examination of the hands all the changes are remarkably symmetrical. There are nodular swellings of the soft tissues of all the phalanges except the third, and there is slight bone atrophy of all the bones of the hands and wrists which is more pronounced in the right hand.

Both thumbs show proliferation about the distal joint, the right presenting the greater change. In the head of the proximal phalanx of the left thumb there is an area of decreased density.

The distal end of the second phalanx of the left index finger presents an area of decreased density and obliteration of the distal joint. The distal joint of the left third finger is narrowed and irregular in outline. Both little fingers show punched out areas of decreased density in the second phalanges, the joint space in the left being irregular and narrowed. The corresponding joint on the right is entirely destroyed, the process involving the distal and proximal phalanges.

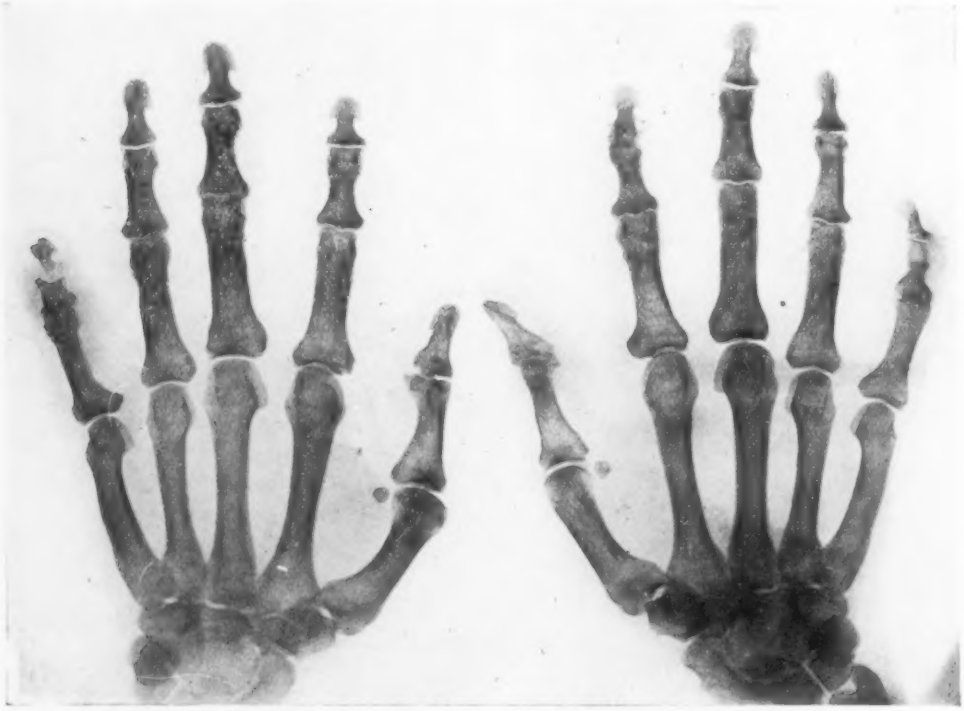

FIG. 4. CASE II.

There is an area of decreased density near the styloid process of the left ulna and styloid process is blunted. The right ulna also shows the beginning of a similar change. The base of the proximal phalanyx of the second finger of the right hand shows a

notched appearance. Bruce's nodes are present in the first, second and third fingers of the left hand and in the first and fifth of the right.

Summary of the radiographic findings: The changes are atrophic, destructive and somewhat symmetrical, with very few proliferative changes. The destructive changes are of the nature of small, punched-out areas of decreased density, the exception being the right little finger where the joint is also destroyed, apparently due to extension of an area of decreased density involving this part.

FIG. 5. CASE III.

FIG. 6. CASE III.

CASE 3. G. W. L. Med. No. 2929. White, male, aged sixty-eight. *X*-ray No. 210. Diagnosis: Gout; tophi.

Hands: In the examination of the hands the right five and the left second and fourth fingers show marked nodular thickening of the soft parts. The third finger of the right hand has been amputated proximal to the distal phalangeal joint. Bone atrophy is present in varying degrees in all the phalanges and in the bones in the region of the nodular thickenings are many exostoses, the bones themselves showing circular and irregular areas of decreased density. The phalangeal joints in these regions show narrowing of the joint spaces, the articulating surfaces of some of these joints being irregular in outline with some destruction of the condyles with consequent distortion of the member. Many of the other phalangeal joints show narrowing of the joint space. The heads of the third and fourth right metacarpal bones present spur formation on the mesial margins with slight narrowing of the corresponding joint space. The remainder of the metacarpal bone and the bones of the wrists show no definite changes.

Feet: The left fourth toe is missing distal

to the middle of the proximal phalanx. There is slight hallux valgus in both feet. The bones of the feet show bone atrophy. The heads of both first metacarpal bones show slight proliferative changes and punched-out areas of decreased density. Both metatarso-phalangeal joints show slight narrowing of the joint spaces, also proliferative changes. The articulating surfaces of these joints are irregular in outline. The heads of both fifth metatarsal bones are irregular in outline, the irregularity presenting a mottled appearance. The joint spaces are narrowed with no evidence of proliferative changes. The articulating surfaces of the proximal phalanx of this joint are not irregular. The second phalanx of both fifth toes show punched-out areas of decreased density.

Summary of the radiographic findings: The feet show principally bone changes, the punched-out areas of decreased density predominating, two joints being slightly involved. In the hands the changes are nearly all arthritic changes, with slight involvement of the bones forming these joints.

Case 4. J.F.S. O.D.D. No. 36014. White, male, aged forty-two. Diagnosis: Gout, tophi.

ROENTGEN REPORT NO. 9216

Hands and wrists: There is a moderate degree of atrophy of the lower end of the radius, ulna, the bones of the carpus, metacarpals and phalanges of the left hand. There is a very slight amount of atrophy of the right carpus and the hand. The carpal joints appear normal. The inner margin of the base of the first phalanx of the right hand shows proliferative changes. The articular surfaces of the bones forming the right third metacarpo-phalangeal joint are in contact and their outlines are irregular. There are proliferative changes of the ends of both the bones of this joint. The middle finger of the right hand is a little shorter than the corresponding finger of the left hand. The other joints of the hands appear normal. In the head of the first metacarpal bone of the right hand is a small, oval area of decreased density. A similar area is present in the proliferative changes described in the base of the first phalanyx of the right index finger. On the dorsum of the right hand is a nodular area of thickening of the soft tissues above five centimeters in length.

Feet: All the bones of the tarsi, metatarsi and phalanges show a moderate amount of atrophy. All the tarsal bones show slight mottling. The bases of the third, fourth and fifth metatarsal bones of the right foot show mottling. The tarsal and tarso-metatarsal joints are for the most part not clearly defined in the plate, probably due to position. Those which are outlined appear normal. The terminal outer four phalangeal joints on each foot are distorted by position. The remaining joint spaces of the feet are normal in appearance. There are slight proliferative changes at the margins of the articular surfaces of the bones entering into the formation of the first metatarso-phalangeal joint of both feet. The inner portion of the head of each first metatarsal bone shows proliferative changes, is decreased in density and irregular in outline. The left great toe shows slight hallux valgus. The mesial outline of each first cuneiform bone is scalloped, due to notching with semicircular areas of decreased density. Similar changes are present on the mesial surfaces of the distal ends of the first phalanges of the halluces. In the proliferative changes described in the heads of the first metatarsal bones are small, more or less circular areas of decreased density. Two similar areas are found in the head of the fifth metatarsal bone of the left foot.

Summary of the radiographic findings: More or less generalized bony atrophy occurred. There was a small amount of proliferative changes. One joint space was obliterated with irregularity of the joint surfaces. Most of the joints appeared normal. Focal areas of decreased density were found. Modular thickening of the soft tissues were present.

CASE 5. F. J. S. Med. No. 6154. White, male, aged forty-three. Diagnosis: Gout; tophi; obesity.

ROENTGEN REPORT NO. 9454

Hands and wrists: There are no bony changes.

Feet: There are slight proliferative changes of the margins of the articular surfaces of the bones forming the metatarso-phalangeal joints of both halluces. All other joints are normal. The head of the left first metatarsal bone shows a localized area of decreased density in its mesial portion. The area is figure 8 shaped. Its long diameter is 12 millimeters. Its borders are only fairly well defined. There is hallux valgus and pes equinus.

Summary of the radiographic findings: Slight proliferative changes affect the bones of the first metatarso-phalangeal joints. A focal area of decreased density is found in the head of the left first metatarsal bone.

CASE 6. A. L. E. Med. No. 5297. White, male, aged forty-eight. Diagnosis: Gout; tophi; cirrhosis of the liver; questionable nephritis.

ROENTGEN REPORT NO. 1486

Hands and feet: The soft tissues present slight fusiform thickening with a tendency to be nodular in the fingers. Slight bone atrophy of all bones of the hands. The terminal joint space of the left little finger is narrowed, and proliferative changes are about the margins of the joint. The joint surfaces are irregular. Other joints of the fingers of both hands show narrowing of the joint spaces. Punched-out areas of decreased density are present in the head of the left ulna, carpal bones, and the left first metacarpal bone. The right ulna shows blunting of the styloid process.

Radiograms of the feet show bone atrophy of all the bones with diffuse mottling of the tarsal bones of both feet with slight proliferative changes. In the head of the right first metatarsal bone near the mesial margin a diffuse area of decreased density is present.

Summary of radiographic findings: The changes in the hands and feet show principally bone changes, with practically no arthritic changes.

CASE 7. P. A. Med. No. 10814. White, male, aged forty-nine. *X*-ray No. 14570. Diagnosis: Gout; tophi.

Feet: There is slight narrowing of the metatarso-phalangeal joint of the right great toe. There are slight proliferative changes of the margins of the articular surface of the phalanx entering into this joint. There are proliferative changes of the margins of the articular surface of the phalanx entering into this joint. There are proliferative changes about a sesamoid bone just internal to the head of this metatarsal. All other bones and joints are normal. The head of the first metatarsal bone of the right foot on the mesial surface shows two small well-defined semicircular areas of decreased density about 3 mm. in diameter.

Summary of radiographic findings: There are slight proliferative changes and focal areas of decreased density in the head of the first metatarsal bone of the right foot.

CASE 8. W. C. B. Med No. 10684. White, male, aged sixty-one. Diagnosis: Gout; tophi; chronic nephritis.

ROENTGEN REPORT NO. 14369

Feet: The heads of both first metatarsal bones and the first phalanx of the left hallux show small circular areas of bony absorption, from 1 to 2 mm. in diameter. The inner surface of the head of the left first metatarsal bone presents a mottled appearance. There is thickening of the soft tissues overlying the metatarso-phalangeal joint of the left foot. No joint changes are present.

Summary of radiographic findings: Focal areas of decreased density occur in the heads of the first metatarsal bones.

CASE 9. A. S. Med. No. 10630. White,

female. Diagnosis: Gout; tophi; chronic nephritis; aortic insufficiency.

ROENTGEN REPORT NO. 14154

Hands and wrists: The bones of the hands and wrists are normal.

Feet: The bones of the ankle joints and of the tarsus are normal. The heads of both first metatarsal bones show small, fairly well defined, circular areas of decreased density. Otherwise there are no abnormal findings.

SUMMARY AND CONCLUSIONS

The soft tissues may or may not show nodular thickening of the soft tissues (tophi). These may be small or very large. The bones may show general bone atrophy, which process may be evenly distributed, or it may be irregular in its distribution. There is a marked tendency for the process to be symmetrical. In the arthritic variety the changes are both proliferative and destructive. The proliferative changes occur about the joints and along the shafts of the bones near the ends. They often appear as small knobs—exostoses (Bruce's nodes). Spur formation also occurs at the attachments of the tendons and ligaments. Destructive changes occur in the joints and are shown by narrowing and obliterating of the joint spaces and irregularity of the articulating surfaces. These joints resemble those seen in chronic infectious arthritis.

Another destructive process is the punched-out areas of decreased density. These are found in the heads of the first metatarsal bones, the bones of the wrist, the head of the ulna and radius, and in the bones of the phalanges. In the region of tophi the bones show proliferative changes and the punched-out areas of increased density, or there may be no visible change.

Radiograms of Cases 1, 2 and 3 are reproduced (Figs. 1 - 6), as they illustrate the different types of the processes shown in the series. It will be noted in Case 1 that the changes are practically all proliferative and that nearly all the joints are involved. There are very few of the punched-out areas of decreased density, the process being confined to the joints or their immediate vicinity. In Case 2 the changes are found principally in the bones themselves, the most prevalent change being the punched-out areas of decreased density, and the joints showing practically no changes except where in close proximity to the bone changes themselves. Case 3 is still another type and is a blending of the two previous types. The feet show principally punched-out areas, while the hands show arthritic changes and proliferation or exostoses about the shafts of the bones (Bruce's nodes). Case 1 is the only case that shows changes in the joints alone. Cases 2, 6, 7, 8, 9 show changes that are confined to the bones alone, the joints presenting practically no involvement. In cases 3, 4, 5 the joints and bones show changes. In case 4 the arthritic changes are confined to one joint in the hands while the bony changes are found in the feet.

For purposes of comparison radiograms of the hands and feet of 100 consecutive cases of non-gouty arthritis were studied. Among these 100 cases there occurred all the types of arthritis and also the punched-out areas of decreased density, similar to those which had been found in gout. The punched-out areas of decreased density were found in 13 of the non-gouty cases. From these findings it is evident that there are no radiographic findings in the hands and feet which are diagnostic of gout. But the types of arthritis described as occurring in gout and the punched-out areas of decreased density are changes very suggestive of gout.

The similarity between the bony changes found in the radiograms in gout and in the chronic non-gouty arthritides indicate the possibility of a relationship in the etiology of the two conditions. In this connection it is interesting to note that Magnus-Levy [5] states that a certain number of cases diagnosed as non-gouty arthritis are very probably actually gout. This conclusion was based on metabolic studies. Furthermore,

Nichols and Richardson[6] found sodium urate deposits on the articular surfaces of the bones of the knee joint in certain cases which were clinically arthritis deformans.

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DISC ATTACHMENT FOR VICTOR SERIAL TIMER

By HAROLD B. THOMPSON, M.D.

SEATTLE, WASHINGTON

THE accompanying photographs illustrate a simple disc attachment for the Victor serial timer to replace the various discs furnished with the timer, and by means of which a continuous exposure may be made, varying in duration from one-eighth second to ten seconds as desired. This is a great advantage over the interrupted exposure using the regular discs, when it would be necessary to allow more than five seconds to give an exposure of one and one-fourth seconds.

The device consists of a solid brass wheel of the same diameter as the wheels furnished with the timer. The periphery of this wheel is marked in ten equal segments, each being further divided into quarters, and one subdivided into sixteenths. One notch only is provided for breaking the circuit and this notch is insulated on all sides.

To use this device, the double-pole double throw switch (shown on the lawer part of the wall in Fig. 1) used for changing from the timer to the foot switch for fluoroscopy, is opened. The disc is then placed so that the end of the spring on the timer lever arm is opposite the number of seconds or fractions of seconds desired. The clock-work mechanism is then started. Closure of the double pole switch will now start the disc revolving and closing the *x*-ray circuit until the disc has revolved to the open notch, when it will automatically stop and the *x*-ray circuit be broken.

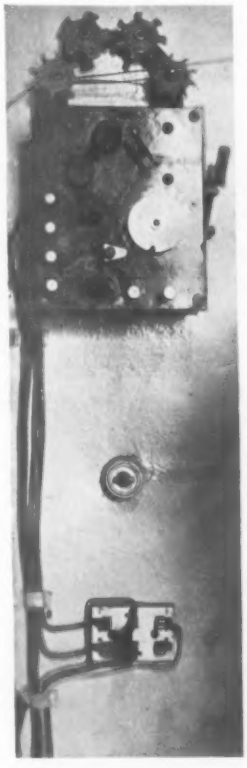

FIG. 1. SHOWS THE NEW DISC IN PLACE ON THE TIMER, REPLACING THE VARIOUSLY NOTCHED DISCS SHOWN ON THE CURVED RACK ABOVE THE TIMER. ALSO THE DOUBLE THROW SWITCH (lower part) WHICH CLOSES THE CIRCUIT THROUGH THE TIMER.

FIG. 2. VIEW (actual size) OF DISC ATTACHMENT.

The device has been found sufficiently accurate for all exposures down to one-fourth second. Shorter exposures are inaccurate on account of the variation in time of starting the disc to revolve by closing the timer circuit.

REPORT OF A CASE OF OSTEO-SARCOMA OF THE TIBIA

By CHARLES EASTMOND, M.D.

BROOKLYN, NEW YORK

The patient is a girl of sixteen who received a blow on the inner side of the leg just below the knee, in the latter part of January, 1920. The blow was produced by the spilling of a toboggan containing two other girls, and in the accident the side of the toboggan struck the leg.

Nothing but a slight degree of tenderness, pain and disability were experienced; but three weeks after the accident the patient went to the school infirmary where she remained in bed for three days. After this rest she felt sufficiently well to resume her studies. During Easter Week in spite of slight pain and disability she was able to ride in the Horse Show. In the early part of the first week of June the leg was roentgenologically examined and a diagnosis of osteomyelitis—possibly tubercular, was made.

She consulted Dr. J. C. Rushmore on June 5th, complaining of pain over the inner side of the knee with slight disability. The pain and disability had not increased markedly during the preceding few weeks.

She was seen by the writer on the same day, when the plates revealed a large area of destruction in the inner portion of the head of the tibia involving about one-half the diameter of the bone. Distinct tumor formation could be observed in the soft tissues to the inner side of the area of bone involvement, together with the presence of detritis and new bone formation. The joint surface was unaffected. A diagnosis of osteosarcoma was made. At the suggestion of Dr. Rushmore the films were submitted to Dr. F. H. Baetjer, who concurred in the diagnosis.

On June 9th an exploratory operation was performed for the purpose of determining the nature of the growth with the removal of a considerable section. The specimen was examined by Dr. Archibald Murray of Hoagland Laboratory, who made a diagnosis of spindle-cell fibro-sarcoma. The specimen was also examined by Dr. Jessup of New York, who confirmed the diagnosis. Amputation at the middle third of the thigh was performed on June 11th. Primary union of the stump occurred and the patient was on crutches on the fourteenth day.

COMMENT

This case is reported not because of its rarity but because of:

FIG. 1. OSTEO-SARCOMA OF HEAD OF TIBIA.

1. The difference of opinion on the two roentgenological examinations.
2. The marked rapidity of the growth.
3. Because of the thoroughness of the examinations, with checking up at every stage.
4. Because of the slight loss of time between the initial diagnosis and the completion of the case.

In the author's experience cases of this type do poorly and metastases develop at remote points with a fatal termination in a comparatively short time.

GLASS IN THE HAND

By A. R. TAFT, M. D.

CHARLESTON, SOUTH CAROLINA

A TOW-BOAT captain, twenty-eight years of age was referred for examination of the hand. While at sea, in attempting to close a window during a gale he cut his hand with broken glass. The wound under ordinary dressings healed by first intention, but he continued to have sufficient pain while using the hand and especially while flexing it, to make it necessary to use the other hand entirely.

When first seen here he had a scar about three centimeters long on the dorsal surface of the left hand between the thumb and the metacarpal of the first finger. Stereoscopic plates showed a foreign body, three cm. long and one cm. wide extending from the inner edge of the metacarpal bone of the thumb, dorsal surface, across the palmer surface of the metacarpal of the index finger to the inner edge of the metacarpal of the second finger.

There were also three small bodies situated in front of the outer end of this larger body. All of these, from the history and general density were taken, correctly, for glass.

Incision was made by Dr. Cathcart in the palmer surface over the superficial palmer area about 4 cm. long. Another horseshoe incision over the scar, and the pieces described were removed. The incision healed rapidly by first intention.

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MAYO CLINIC
ROCHESTER, MINNESOTA

DR. H. M. IMBODEN, *Editor,*
AMERICAN JOURNAL OF ROENTGENOLOGY,
480 Park Ave., New York City.

Dear Sir:

Enclosed please find a copy of the report of the Research Committee which was made at the meeting of the Radium Society in April at New Orleans. It is the desire of the Research Committee that an accurate and uniform record be kept of all cases treated with radium. In this way, uniform statistics may be collected, even though the treatment is given by many different individuals.

Very truly yours,
LEDA J. STACY.

SCHEDULE SUBMITTED BY RESEARCH COMMITTEE

1. Keeping records of all cases treated.
   1st page: Short history, diagnosis, grouping based on physical findings.

   2nd page:

Case No.	Date of Treatm.	Amt. of El. or Emanation Screening	Duration	Total mg. hours or mc. hours

2. Grouping of cases:
   A. Operable
   B. Borderline or doubtfully operable
   C. Inoperable
   D. Advanced and hopeless
   E. Recurrences—local, regional
3. Determination of E. S. D. of each tube of radium. The E. S. D. should be the standard of comparison of sensitiveness of the various elementary and diseased tissues.
4. The methods of screening and protection of healthy tissues surrounding—(a) distance; (b) material used.
5. The importance of postmortem examinations and serial sections of organs *in toto*, this being the only means to determine the correctness of the technic and the actual permeability of the rays, thereby establishing the actual therapeutic value of radium rays.
6. The re-examination of all patients at stated intervals and careful recording of subjective and physical findings at each examination (both visible and palpable).

TRANSLATIONS & ABSTRACTS

HONEIJ, JAMES A., M.D. Cavity Formation and Annular Pleural Shadows in Pulmonary Tuberculosis. (*Arch. Int. Med.*, Vol. 25, No. 1, January 15, 1920.)

The signs of cavity in the lung, both on physical and roentgenologic examination, have always been a matter of interest and inquiry. The present paper aims to give added information on the subject, based partly on the examination and observation of a large number of cases in a tuberculosis hospital. Some years ago the author's attention was drawn to shadows in roentgenograms suggesting cavities, although no physical signs of cavity formation were present, and for a considerable length of time the failure to substantiate by roentgenologic means cavity signs obtained on physical examination has been noted. This inquiry covers cases with definite cavity formation and its classical signs, cases giving fair clinical evidence of cavity but not proven by roentgenologic methods, and cases giving certain roentgenologic images ranging from true cavity formation to a simple pleural thickening, without clinical evidence.

Roentgenographic Findings: These will be taken up in the following order: 1. Cavity. 2. True annular shadows. 3. Intrapulmonary annular shadows.

1. *Cavity:* The basis for the study of cavities from a roentgenographic point of view rests on postmortem findings and statistical data. The point regarding the pathology of cavitation emphasized in the first paper of this series applies, of course, here. Not all cavities are visible roentgenographically. Size by itself is not important; small cavities, 2 cm. in diameter, are frequently outlined more clearly, are more transparent and are more readily and correctly diagnosed than are larger cavities. It is, therefore, necessary that cavities, irrespective of size, be in such a position that the greater number of factors in diagnosis play a part. Cavities at the apex usually show more clearly than those at the base, provided the cavities which are compared are similar in size, type, and so forth. However, the fact must be borne in mind that there is a less depth to the lung at the apex, and less degree of congestion and secretion with gravity to play a part. Likewise, cavities occurring in or just outside the hilus area are more difficult to diagnose. This is largely because of the depth of the lung. In addition, the picture may be complicated by hilus shadows, congestion or fibrosis. Very often the cavity may be overshadowed, while occasionally a localized emphysema may be present. Provided other factors are taken into account, cavities which occur in the full pulmonary field are detected more readily than in those parts of the lungs where the shadows and outlines might be confused with them. Position, therefore, is of importance. The depth of the cavity—whether it occurs near or under the surface of the lung, or deep in the lung—is important. If situated deep in the lung, then the size of the cavity is undoubtedly an important factor; but the important point is the exact position and size of the cavity in the lung. The contrast between cavity and lung tissue must be noteworthy; that is the transparency in the area of cavitation must be greater than the normal transparency in that part of the lung, and, naturally, greater than that of the tissue surrounding it. It is, therefore, important that close attention be paid to the tissue changes surrounding an area of transparency. Usually, the greater the infiltration, or the more solid the lung, the greater the evidence that the area of transparency under observation, surrounded by this area of infiltration, is a cavity. From the roentgenographic point of view this infiltration will show as a more or less irregular heavy density greater than the usual mottling. If the density is more even and, perhaps, more opaque, then, in all probability, we are dealing with a pneumonia type of tuberculosis. It is obvious that in speaking of cavity he has in mind the result of necrosis and softening in an infiltrated area. Therefore, one should always bear in mind the pathology of different tuberculous processes when examining roentgenograms for possible cavitation. The duration of the disease indicates usually what may be expected besides the usual tuberculous changes; frequently repeated healing or breaking down may cause other tissue changes; fibrosis, for instance, or if the surface of the lung is involved, pleural changes and in consequence, extra shadows and increased density with numerous ouutlines. Under these additional conditions the transparency of the suspected area will be lessened and

its outline confused. The transparency of the cavity will vary just as much as the tissue density around it. This will depend (apart from the factors already mentioned) on the amount of air in the cavity. It must be in greater amount than the secretion or fluid present. The greater the amount of fluid present, the less likely will it be seen, and vice versa. If the cavity is large and the secretion abundant, change of position of the patient from the prone to the upright posture will bring about a change in density or of fluid level. The lower portion of the cavity will then be denser than the upper portion and the upper outline will be clearer. The transparency of the area and the surrounding tissue density also may vary from week to week, may vary with inspiration and expiration as seen under the fluoroscope, and will, of course, vary if acute conditions are superimposed which will produce congestion and, perhaps, added secretion. It is impossible to diagnose cavities when the density of the lung around the cavity (that is, back, front, or back and front of the cavity) is greater than the transparency. This is especially true if the cavity is small or filled with secretion. The outline of the cavities or areas suspected of being cavities is of diagnostic importance, but only after the above points have been considered. Cavities may have a clear cut, sharply demarcated outline, clearly differentiated from the surrounding tissue; or they may have an irregular, obscure outline that fades into the surrounding lung substance. The first condition usually indicates a fibrous wall; the second, cavity with continued destruction of lung tissue without definite walls or fibrous tissue outline. The first type of cavity is usually chronic, although the reaction of the lung tissue may be quite marked in acute self-limiting cases. In those cavities with a fibrous wall one can also invariably find shadows indicating fibrous tissue elsewhere in the lung. Under these circumstances one must particularly take into consideration the shadows produced by thickened pleura, the outline of which may be confused with the fibrous wall outline of a cavity or cavities. This is especially true if the outlines of several cavities are superimposed one on another. These cases are most often easy of diagnosis, provided one can definitely eliminate shadows produced by the pleura. The shape of cavities aids in the diagnosis. Circular or oval areas, even and regular in outline predominate in the majority of cases. A true cavity, especially one with fibrous wall, is seldom anything but oval or circular. In cases where cavity outlines are superimposed one over the other care should be taken that the resulting irregular outlines are not confused with the regular outline of a single cavity. Likewise, outlines of the rib, the border of the scapula or of the mediastinum, bronchial markings, or bands from a thickened pleura may be confused with the outline of the cavity. Lastly, the unilateral symmetry of the thorax must be taken into consideration, contraction of the rib spaces, the increased angle of the ribs themselves from the spine, and the narrow bony apical outline, as well as the total narrowness of the thorax; in short, any appearance of the thorax to indicate lack of respiratory effort or lack of lung function, and, therefore, immobilization of the chest wall, especially if in contrast to the opposite side. If there is cavitation at the apex, it is surprising to see the degree of contraction or collapse that takes place in the thorax wall from the apex to the third or fourth ribs. The physical findings should be included in all cases of cavitation, especially when the roentgenogram fails to give complete or definite evidence.

True Annular Shadows: These shadows are produced by the pleura. They have no relation to pulmonary infiltration or softening and breaking down of lung tissue. It is true that the two conditions may coexist, but it is equally true that pleural changes may be secondary to cavitation or vice versa. Consequently, if a case is presented in which cavitation is accompanied by a pleural annular shadow, it is generally impossible to differentiate the two conditions.

Intrapulmonary Annular Shadows: In a small percentage of cases these shadows occur in the full pulmonary field. Invariably, they are just outside the hilus area, one border of the ring shading off into the hilus itself. Although very rarely mistaken for cavities, these shadows may easily be confused with pleural annular shadows. Intrapulmonary annular shadows are rarely as regularly oval or circular as true annular shadows. Their walls commonly resemble perbronchial thickening and in the majority of cases a well defined communication is seen between the shadow and bronchi at the hilus or in the full pulmonary field. The inner border of the shadow does not differ

from the outer; both are slightly irregular or fuzzy in outline. The transparency of the inner area is no greater than that of other portions of the lung. These shadows can invariably be diagnosed. If closely examined with the stereoscope, it will be found that the medial portion of the shadow, that is, the portion resting on the hilus, is heavier than the distal portion, and that it is definitely bronchial and hilic in origin. The distal portion fades off, and ordinarily the two points which form an arc or the outer half of the annular shadow, are separated. The stereoscope definitely indicates that intrapulmonary annular shadows are formed by two or more bronchial or root branches, and that they are neither pleural nor cortical in origin. These intrapulmonary shadows are seldom seen either in the second or in the advanced stage of tuberculosis. Indeed, if tuberculosis is present to any marked degree, these shadows are made out with difficulty. They are due to definite fibrous peribronchial changes and do not disappear. With the exception of aiding in ruling out tuberculosis, clinical evidence seldom assists in the diagnosis.

SUMMARY

There are three conditions which at times may be confused and which make a differential diagnosis difficult or often impossible. These include (a) true cavitation in pulmonary tuberculosis, with and without fibrous walls; (b) true pleural annular shadows, with and without pulmonary disease; (c) false annular shadows of intrapulmonary bronchial origin, occurring in early pulmonary tuberculosis and other chest conditions. These three conditions are illustrated here. He shows that a clear understanding of the pathologic processes involved and thorough appreciation of the different clinical signs are needed, and since, in a broad sense, we are less interested in the presence or absence of cavitation than in its effect on diagnosis, treatment and prognosis, it is essential carefully to consider other acute or chronic lung lesions in conjunction with the direct evidence of cavitation. Apical pleural adhesions are, of course, of much greater weight in the diagnosis of pulmonary lymphatic tuberculosis than are similar changes at the base. However, the mere presence of an apical annular shadow, although it may be due to the same process which occurs frequently at the base invariably leads to a more serious diagnosis than is warranted. If the movement of the lung at the apex were as great as at the base (all other conditions being equal), probably fewer annular shadows would result from pleural thickening. If tuberculosis of the base of the lung occurred more frequently, we would be led, in a large number of cases, to a different diagnosis than that of mere pleural thickening. On the other hand, if every annular shadow depended on a cavitation in the lung, then the frequency of lung cavitation would be increased enormously. Under these circumstances the presence or absence of preceding infiltration is unessential. In many cases distinctly oval or circular areas of transparency which confuse the diagnosis are found. These areas, which are often outlined by bronchial shadows, bony structures or most frequently by the hilus, may be mistaken for cavitation, annular shadows or even bronchiectasis; occasionally they are produced by a localized emphysema. Finally, the physics of roentgenology and the limitations in roentgenologic diagnosis must be remembered. If acute, congestive conditions prevail, it may be impossible to differentiate the lesions mentioned. Repeated roentgenological and physical examinations are, therefore, clearly indicated. The difficulty in determining the presence of a cavity can readily be imagined by a study of the pathologic and roentgenologic findings in this condition. The roentgenologist errs more frequently in failing to diagnose a lesion when it is present than in diagnosing cavitation when it does not exist. Clinically, the reverse is true. A diagnosis of cavitation is frequently made when no cavity is present. This is no reflection on the clinician, for in both physical and roentgenologic diagnosis there are similar limitations.

W. W. BELDEN.

ISER, SOLOMON. The Roentgen Diagnosis of Subphrenic Abscess. (*Journal de radiol. et d' électrol.* Vol. 4, No. 2, February, 1920.)

The author presents the case of a man, aged fifty, with longstanding symptoms of pyloric stenosis. Cachectic condition, no fever. No other clinical findings were submitted to the roentgenologist. Fluoroscopic examination showed the presence of two large sacs filled with fluid; to the left the dilated stomach, to the right a collection of gas and fluid, clearly

subphrenic, which could only be a sub-diaphragmatic abscess. The stomach was immovable, and there was no peristalsis visible. During the entire examination no barium escaped from the stomach.

Pressure in the right hypochondrium was very painful. The long duration of the symptoms, the appearance of the stomach, and the fact that carcinoma is almost never complicated by subphrenic abscess led to the diagnosis of pyloric ulcer, and subphrenic abscess following perforation. Operation revealed a subphrenic abscess. The patient died, and autopsy disclosed the following: enormous, well encysted abscess, whose walls were formed by the convex surface of the liver, the stomach and the abdominal wall. Large perforated ulcer in the pyloric region, and a little higher up an ulcer perforating into the pancreas.

L. S. Goin, M.D.

Dandy, Walter E., M.D. Localization or Elimination of Cerebral Tumors by Ventriculography. (*Surg., Gynec. & Obst.*, Vol. XXX, No. 4, April, 1920.)

It seems incredible that a brain tumor as large as one's fist can exist in either cerebral hemisphere and still escape localization by expert neurologists and neurologic surgeons. Yet nearly all cerebral tumors eventually attain this size, and a very high percentage of them can neither be accurately localized before operation nor be found by an exploration of the brain. In a recent analysis of a series of 70 cases with neoplasm of the brain, Dr. Heuer and Dr. Dandy have shown that of forty-five cases which were presumably located in the cerebral hemispheres, twenty, or 44.4 per cent, escaped detection at operation; and at the time of that publication they considered this a high record in verifying the location of cerebral tumors. This percentage is not strictly correct, for several of the cases were submitted to more than one operation before the tumor was disclosed. On the other hand, in many cases which seemed to present definite signs of localization, the tumor could not be found because it was situated too deeply in the brain. A more careful analysis of these figures disclosed to an even greater extent the limitations of the neurological signs which are helpful in localizing brain tumors. Nearly all of the tumors which could be localized with certainty were in one of three locations, in each of which the signs are pathognomonic: (1) hypophyseal or third-ventricle tumors gave the characteristic disturbances of the optic tracts and destruction of the sella turcica; (2) precentral or postcentral lesions were evident by the contralateral motor or sensory disturbances; and (3) neoplasms affecting the motor or sensory speech centers produced the typical deficiencies of speech. The remaining cases which were localized exclusively by other methods, such as changes in the eye-grounds, disturbances of the other cranial nerves, etc., really comprised a very small group. There is only one satisfactory form of treatment for brain tumors, i.e., complete operative extirpation of the tumor. It is not conceivable that neoplasma of the brain ever disappear spontaneously or are cured or even benefited by any form of medical therapy. Nor, in our experience, has radium or the *x*-ray produced even temporary beneficial results.

Procedure for localization of the tumor by ventriculogography: Each lateral ventricle occupies a large area in the interior of either cerebral hemisphere. It is evident that a tumor of any size situated in either cerebral hemisphere will modify the shape, size, and position of the corresponding lateral ventricle. Quite frequently the lateral ventricle in the opposite hemisphere will be dislocated and its size also will be greatly modified. These changes in the ventricles, both homolateral and contralateral, yield many opportunities for locating brain tumors by ventriculography. Fortunately following the injection of air into one lateral ventricle, it is possible to obtain a roentgenogram of each lateral ventricle separately, and thus determine alterations produced by a tumor in either cerebral hemisphere. Owing to the angles of the ventricular system, it is possible to fill only one lateral ventricle with air when the head is in a given position. After a roentgenogram has been taken, the head must be carefully turned in such a manner that the air can pass the various ventricular angles and the interventricular foramina (of Monro) and the third ventricle, and thus reach the opposite lateral ventricle. After a lateral view of each ventricle has been photographed, the head should again be carefully turned in order to direct the air into the anterior horns of both lateral ventricles; the occiput will then be on the plate and the roentgenogram will give the

size, shape, and position of the anterior part of both lateral ventricles. Then by placing the forehead on the plate, the size and position of the body, and of the posterior and descending horns, can be demonstrated. It would seem that most tumors must give some manifestations of their presence in one of these views, and the findings must therefore absolutely indicate the position of the tumor. To introduce air into the ventricle of an adult, it is of course necessary to make an opening in the skull. This can be done either under local or general anesthesia, the choice largely depending upon the patient. Personally, I prefer local anesthesia with a responsive patient. The procedure need be but slightly painful and after transferring the patient to the *x*-ray room his cooperation eliminates respiratory movements and allows a much better exposure; moreover a considerable period of anesthesia is avoided during the time necessary to dress the wound and transfer the patient to the *x*-ray room. A ventriculogram will in many cases at once tell whether the tumor is cerebral or cerebrellar. In the latter cases an inter hydrocephalus will be evident by the symmetrically enlarged lateral ventricles. In some cases it will be found that the size of the ventricle has been so reduced that it is impossible to withdraw sufficient fluid to make the injection of air a safe procedure. It is then best to make a ventricular puncture on the opposite side and inject air into this ventricle, though occasionally both ventricles are too small. Not infrequently we can localize a tumor merely by the difference in the size of the two lateral ventricles as determined by the ventricular puncture or often by the abnormal position at which either ventricle may be reached. In a general way a very small ventricle is presumptive though of course not absolute evidence of a cerebral as against a cerebellar tumor or a tumor of the brain stem; when there is a difference in the size of the two lateral ventricles the tumor is usually on the side of the smallest ventricle. Even a bilateral ventricular puncture, which is only occasionally necessary is a small procedure compared to an exploratory craniotomy or even to a decompression, and the results obtained in localization of the growth not infrequently make the puncture far more valuable than an exploratory craniotomy. In infants and very young children, a puncture can be made through an open fontanelle or through sutures which have been separated by the abnormal pressure. During the past six months he has used ventriculography in over 75 cases from Professor Halsted's clinic. The majority of these cases had hydrocephalus; in many cases ventricular dilatation was suspected and the injection of air made the diagnosis certain. In many others the injection was made in order to determine whether the disease was progressive or stationary, in other words, as a means to determine whether or not operative treatment should be instituted. These cases will not be considered here but will appear in a subsequent paper. He describes here only the instances of tumors in the cerebral hemispheres or for very strong reasons suspected of being located there, and only those in which the ventriculogram has been the sole means of diagnosis. In many cases the localization of the growth has been easily determined by signs and symptoms and in such instances there is at present no purpose in instituting ventriculography, though he feels that eventually this method may be important in differentiating the type of tumor and determining the kind of operative treatment which is necessary. This possibility is strongly suggested by two of the cases described, but such a decisive stand in treatment, which in many cases might eliminate exploration of the tumor, will only be determined by an extensive experience in the interpretation of the *x*-ray findings in a large series of brain tumors. He describes five cases, each representing entirely different findings and showing the range of usefulness of this procedure when tumors of the cerebral hemisphere are suspected. Ventriculography will be seen to exclude a cerebral tumor when the lesion is situated elsewhere; precisely to locate the tumor when it exists in either cerebral hemisphere. In two of these cases there was no localizing sign by which the location of the tumors was even suspected. In both, the ventriculograms showed the precise location of the growth. In one case the tumor was entirely removed and the patient is now well; he had previously submitted to two exploratory craniotomies but the tumor could not be found. In the second case a decompression had been done; after localization of the tumor by a ventriculogram, a very large infiltrating glioma was found at operation but could not be removed. The patient was spared further useless operations by the ventriculographic localiza-

tion of the tumor. In a third case the signs were differently interpreted; a large localized bulging in the right temple seemed to indicate an underlying tumor. There was a complete sensory and motor paralysis of the trigeminal nerve which could have resulted from pressure on the gasserian ganglion; or the paralysis might have been due to involvement of the trigeminal root in the posterior cranial fossa. The ventriculogram conclusively determined the location. In a fourth case, an exploratory craniotomy in a case of focal epilepsy disclosed a greatly dilated ventricle—apparently hydrocephalus; subsequently the ventricles were injected with air and the ventricular dilatation was found to be unilateral—a very rare condition. A fifth case can hardly be included as a result following ventriculography for air could not be injected, but the attempt at the procedure was responsible for locating the tumor. The ventricle was found by a ventricular puncture to be markedly dislocated to the left, but it was so small that only a few drops of fluid could be obtained from the needle. Under such conditions it is not safe to inject air. The dislocated position of the ventricle could only be caused by a tumor in the opposite side of the brain. The extremely small size of the ventricle must be due to the intracranial pressure produced by the tumor. The neoplasm was found in the right prefrontal region and completely removed.

CONCLUSIONS:

1. Ventriculography is invaluable in the localization of obscure brain tumors. So-called unlocalizable tumors comprise at present over half of the total number.

2. Practically all brain tumors either directly or indirectly affect some part of the ventricular system.

3. Hydrocephalus is easily demonstrable by ventriculography and when present usually though not always restricts the location of the tumor to the posterior cranial fossa—that is, the brain stem or the cerebellum.

4. Local changes in the size, shape, and position of one or both ventricles as shown by the ventriculogram will accurately localize most obscure tumors of either cerebral hemisphere.

5. Every effort should be made to localize the tumors before resorting to any operative procedure.

6. The usual subtemporal decompression is useless and dangerous when a hydrocephalus is present, that is when the tumor is in the brain stem or cerebellum.

7. A suboccipital decompression (cerebellar operation) is extremely dangerous when the lesion is in the cerebral hemispheres.

8. To differentiate between cerebral and cerebellar lesions is frequently one of the most difficult tasks in intracranial localization. Ventriculography at once separates these two groups and indicates the operation of choice.

9. The only cure for brain tumor is extirpation. The results in terms of complete cures of brain tumors will be in proportion to the early localizations which are made. A decompression is a purely palliative procedure and should be adopted only when the tumor cannot be located. Ventriculography permits of an early and accurate localization of the growth when all other methods fail.

10. It is possible to get a separate profile ventriculogram of the whole of each lateral ventricle. Any change in size or contour is easily demonstrated. Anteroposterior views will show the same points in cross section but they are chiefly useful in showing any lateral dislocation of the ventricles.

11. The results in localization of five types of cases of brain tumor are shown with ventriculograms. In all but one of these, the ventriculogram was the only means by which a positive localization could be made. One tumor occluded a lateral ventricle and dislocated both lateral ventricles. Another tumor altered the size and shape of one lateral ventricle. In a third case a cerebral tumor, though suspected, was eliminated by the hydrocephalus. In a fourth case a unilateral hydrocephalus was demonstrated.

12. Occasionally the size of both ventricles is so reduced that air cannot be safely injected. In one case the dislocated position of both ventricles, which were greatly reduced in size, made the localization possible.

13. Ventriculography is also useful in precisely localizing the growth. This permits of an exploration directly over the tumor and greatly simplifies the operative procedures.

14. Many usleess and harmful operations will be spared the patient by a judicious use of ventriculography.

15. Doubtless the type of tumor will often be indicated by the ventriculogram. Such knowledge will be useful in prognosis and in

determining whether radical or palliative operative treatment should be instituted. These determinations will result from accumulated experience in the interpretation of the ventriculograms together with the correlative operative findings presented in a large series of cases.

16. With experience and care in the use of ventriculography, I believe few tumors will escape accurate localization.

W. W. Belden.

Frank, Louis, M.D., Louisville, Ky. Congenital Diaphragmatic Hernia. (*Ann. Surg.*, Vol. LXXI, No. 3.)

Scudder, in 1912, could find only fifty-three cases of diaphragmatic hernia which had been subjected to operation. Since then a number of cases have been recorded. They, however, conclude that those of congenital origin are exceedingly rare and do not often come to operation. More rare, for evident reasons, are those, whether congenital or traumatic, occurring on the right side.

Of the additional cases recorded in the literature only five were reported as congenital, those observed and operated upon being accounted for largely by the trauma of war. Most of the cases occurred in soldiers as the direct result of missiles. In this type of cases, also, it is a fact, explained by the anatomic position of the liver, that the hernia was almost uniformly upon the left side.

In the description of diaphragmatic hernia there is nothing to surpass—either from an anatomic standpoint, or from close study and analysis of the symptomatology in both strangulated and non-strangulated cases — that written by Cooper in his classical work on hernia published in 1804. He divides diaphragmatic hernia into three varieties, and it is believed his division holds good today. He first classifies them into congenital and acquired. Under the congenital type he describes two varieties, one in which there is a distinct peritoneal sac, in the other there being no sac. The third variety also has no sac, this being entirely traumatic in origin.

A study of the literature confirms Cooper's opinion that congenital herniae of the second variety are rarely seen, as the subjects usually die at birth or shortly afterward. In the first variety of the congenital type the individual may live for quite a period of years, and in his work Cooper mentions such cases, describing also cases of the second variety and of the traumatic type.

Beckman believed that the congenital type could not be benefited by operation, and the opinion was then expressed repeatedly and set forth in text-books on surgery that such herniae should not be operated upon unless they become strangulated, and this seems to have been the general practice. Beckman says the congenital type are not true herniae in that they have no sac. In the face of the reported cases, which have been carefully studied, this contention can hardly be maintained.

Giffin, in 1912, and Scudder in the same year reviewed most carefully and completely all the literature of this subject. At that time about one thousand cases had been recorded, though of these a very large proportion had been discovered only at autopsy. Scudder's study showed that there had been about fifty-three operations performed for diaphragmatic hernia at that time, and of this number thirty-nine patients had died. The thoracic approach was used in eleven, of which seven recovered; the abdominal approach in forty-two, of which thirty-five died. In these fifty-three cases deliberate operations based upon pre-operative diagnosis was performed in only six, the other patients applied to the surgeon for relief of intestinal obstruction; and, as he says, this is most likely the cause of the high mortality.

Recently, as has already been said, probably as a result of war wounds, the subject has again been brought to the attention of the profession particularly by Soresi, in a paper published during the current year. He reports one congenital and two traumatic cases, suggesting a method of closure to insure against recurrence of the hernia. We may say, in passing, that we know from experience it is not always possible to successfully execute a previously planned procedure for permanent cure in these cases. This is also well illustrated by Downes' case of congenital hernia in a boy about seven years of age, where it was impossible to restore the viscera to the abdominal cavity, necessitating, on account of the extreme condition of the child, a gastro-enterostomy to prevent starvation.

Downes believes from his experience that the abdominal approach is better, because in congenital cases where hernia has occurred

through a dilated opening it may be impossible to correct the condition by approach from above. In their own case, it was impossible to deal successfully with the condition through the abdominal incision, necessitating a transthoracic operation.

Attention is called by the author last quoted to the possibility of mistaking a full stomach herniated through the diaphragm for pyopneumothorax, and he states that several cases have been recorded in which such a mistake, followed by aspiration, terminated fatally. While in former years there may have been difficulty in diagnosis, it is believed today that with the aid of the roentgenologist and stereoscopic views, the diagnosis can be accurately made in practically every case. In their own case no difficulties were presented after a stereoscopic picture was obtained.

Where a large portion of the stomach is herniated, the clinical history is similar to that of hour-glass or obstructed stomach, except that there are periods of remission and the symptoms begin in early childhood. However, the symptomatology, pathology, and etiologic factors have been so fully discussed in the literature that they are not considered further in this paper, the desire being rather to report an interesting and probably unusual case, with the difficulties encountered in efforts at relief.

W. W. Belden.

Lagarenne and Guilleminot. Pharyngo-Esophageal Diverticula, or Pulsion, Diverticula of Zeuker. (*J. de radiol. et d' électrol.* Vol. 4, No. 2, February, 1920.)

The authors review the literature, and present a case of their own. These diverticula occur entirely, or nearly so, at the pharyngo-esophageal junction, which is normally at the lower border of the cricoid cartilage. Following Mayo, Guisez and others they insist that they must be called pharyngo-esophageal diverticula, rather than esophageal. They arise just above the pharyngo-esophageal junction, and are posterior. The mechanism of their formation is as follows: Arising from the cricoid cartilage are the fibers of the crico-pharyngeal muscle. Passing backward, they divide into two bundles; the superior, which terminated in the mid-line, and the transverse, forming a semilunar fold at the superior orifice of the esophagus. It is between these two bundles that the diverticula occurs. The exciting cause is an inflammation, from caustics, etc. The retching, attempts at swallowing, pressure of ingested food, etc., little by little push the mucosa between the muscle fibers, and the diverticulum is formed. The diagnosis is easily made by fluoroscopy. The treatment is surgical, and consists in extirpation of the pouch.

L. S. Goin, M.D.